HANDBOOK

OF

ELECTRICAL METHODS

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COMPILED FROM THE

ELECTRICAL WORLD

McGRAW-HILL BOOK COMPANY, Inc.
239 WEST 39TH STREET, NEW YORK
6 BOUVERIE STREET, LONDON, E. C.
1913

THE · MAPLE · PRESS · YORK · PA

PREFACE

The large and varied amount of reading matter which is published in a technical paper like the *Electrical World* is often an embarrassment of riches for readers who do not make it a practice either to clip and file articles which are of special value to them or to keep indexed bound volumes. After all matter of transient interest has been eliminated there still remain much data worthy of more orderly arrangement and republication in book form. The present compilation is such a classified collection of articles published during the last three or four years in the *Electrical World* on those subjects which relate purely to ways of doing things rather than to design, descriptions of apparatus or to the commercial side of the electrical industry. It will therefore be found of particular value to the practical man who is seeking that kind of useful information which cannot properly be incorporated in the usual handbooks. The original articles have been edited slightly to meet the conditions of publication in book form but no attempt has been made to comment on the facts presented.

New York,
December, 1913.

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HANDBOOK OF ELECTRICAL METHODS

I

GENERAL NOTES

Underground Conduit Work, Pipe Thawing, Soldering Wire, Electrolysis, Portable Rheostat, Etc.

Screen Cover for Manhole Workers.—To protect its workmen in manholes, where traffic is dense, the Commonwealth Edison Company, Chicago, provides each crew with a screen cover of the same size as the standard manhole cover. After the men have gone below, this screen is dropped into place on the sills of the manhole framing, and it admits ventilation to the underground chamber while protecting both workmen and passers-by from accident. The screening is of 1/4-in. interwoven steel wire and is strong enough to bear the weight of a horse.

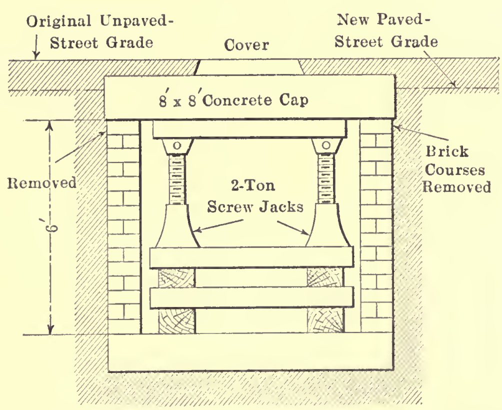


FIG. 1.—ADAPTING MANHOLE IN NEW STREET GRADE, MILWAUKEE.

Adapting Manhole to New Street Grade.—The expense and trouble of wrecking the old concrete cap of manholes when adapting them to new street grades are avoided by Richard Krohn, foreman of the Milwaukee company's underground department, who employs a couple of powerful jacks to lift off the concrete cap so that a course or two of bricks can be

removed, after which the cap is dropped back into place in its new position. As shown in Fig. 1, the 8-ft. by 8-ft. by 7-in. concrete cap, weighing 2 tons, is handled by a pair of 2-ton screw jacks blocked up to the proper height. The internal height of the manhole, 6 ft., leaves ample room after subtracting the width of two courses of bricks. A similar scheme might also be used to raise the cap to a higher grade. Three men, at 20 cents per hour, make the change in cover position in three hours. To wreck and rebuild the concrete cover cap would cost at least $30 for labor and materials, besides requiring several days' time.

Notes on Underground Conduit Construction (By Guy F. Speer).—The matter given herewith is a collection of notes taken during the erection of an underground-conduit system in a New Jersey city with a population of about 23,000.

The Conduit Line.—The trunk line extending through the principal thoroughfare and business section of the town consists of nine fiber ducts, laid three high, with 1 in. of concrete between ducts and a 3-in. envelope of concrete surrounding them. Extensions of four ducts, six ducts and eight ducts are made in several of the side streets to manholes. From these manholes laterals extend to poles whence taps are made to the overhead wires.

The longest section is 530 ft. and the average is 285 ft. For purely transmission purposes the sections should run longer, but for distribution purposes a manhole should be built at every intersecting street at least.

At suitable intervals in the trunk line, depending, of course, on the length of the section and the demands for service connections throughout

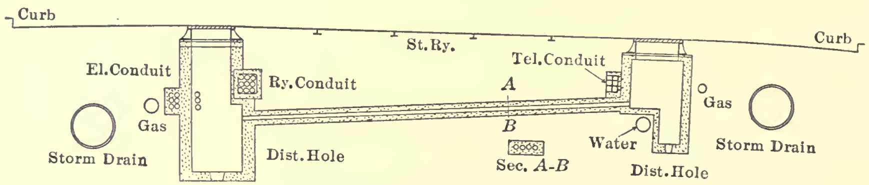


FIG. 1.—CROSS-OVER BETWEEN DISTRIBUTION HOLES.

a block, distribution holes or hand holes should be installed. On the other side of the street from these distribution holes other distribution holes should be built, and the two should be connected by a four-duct cross-over. (See Fig. 1.) In this manner both sides of the street are served without unduly long service pipes and without having to tunnel under car tracks or other obstruction whenever a new service is cut in. This method also eliminates overcrowding of distribution holes. These holes should be spaced on an average 120 ft. apart.

Before beginning excavation on the line described, test holes were dug from curb to curb, except under car tracks, at street intersections to

determine upon which side of the street the main conduit line should be run, and also to discover if space were available for constructing manholes. These test holes were sunk about 7 ft. deep, and the exact location of all obstructions such as gas and water mains, sewer drains, railway and telephone conduits, etc., was noted. In this case the space between the gas main and the railway conduit was not sufficient to permit the building of distribution holes and the main conduit line, and the 10-in. gas main was moved transversely from 2 ft. to 4 ft. for a distance of 1020 ft. The task, including excavating, moving the main, recalking joints, etc., occupied two weeks and cost about $500.

The location of the conduit line being determined, a trench 22 in. wide and 43 in. deep was laid out to line and excavated. Theoretically a trench 18.5 in. wide is sufficient for a nine-duct (three-wide and three-high) line; but to permit a man to work in the trench the latter should be dug wider. The lower portion of the trench may be made narrower, however, and the depth depends on the nature of the obstructions encountered. A grade of 1 in. in 200 ft. is enough to allow for drainage into manholes. Care should be taken to avoid traps or water pockets in the conduit line.

As the soil encountered in building the line in question was hard clay, no side-bracing or sheeting was necessary. Fiber duct (3.5 in. outside diameter and 0.25 in. walls) was used throughout the work except in crossing through the roofs of culverts or large sewers, where 3-in. wrought-iron pipe was used. Fiber conduit is light in weight, cheap, easy to handle and can be laid by unskilled labor. No attempt was made to waterproof the conduit, the concrete envelope forming only a support and protection to the duct. The socket joint was found to be more satisfactory than the sleeve joint, because the latter required more time to fit and the sleeves very often slipped down over the end of the duct, leaving an opening.

After the trench was dug a 3-in. footing of concrete was put in, 1:3:6 mixture with 3/4-in. stone being used. On this footing the duct was laid on 4.5-in. centers, a "rake" being used for this purpose. Concrete was then rammed between the ducts and a 1-in. cover of concrete put on. This process was repeated until the top layer of duct was reached, when a 3-in. cover of concrete was put on. The trench was then refilled, tamped thoroughly and the street opening repaved. During construction care was exercised to keep the conduit as far as possible from the gas main so as to avoid danger of gas leaking into the line and manholes and causing explosions. Moreover, by this means danger of puncturing the ducts when testing or "smelling" for a gas leak is also eliminated.

At street intersections, in the middle of long blocks and at sharp turns in the conduit line large rectangular concrete manholes were built. The sizes constructed were 5 ft. by 7 ft., 6 ft. by 8 ft. and 7 ft. by 9 ft., with 12-in. walls and 6 ft. clear depth. Plenty of head room was allowed so as

to permit cablemen, splicers, etc., to work and to leave space for the installation of transformers. Monolithic concrete construction was employed throughout, a 1:3:6 mixture with 1 1/2-in. trap-rock and Portland cement being used. The concrete was put in quite wet and rammed thoroughly, especially next to the form, so as to give a smooth inside finish when the form was removed.

The frames were made of shiplap, and the hard clay soil eliminated outer forms and sheeting. Section forms were not used, as these required the walls to be built and the form to be taken out before the roof could be put on. The walls and roof were constructed while the one form was in place, and after forty-eight hours this frame was taken apart and removed from the hole. On 5-ft. by 7-ft. holes four 7-ft. second-hand 4.5-in. car rails were used to support the manhole casting and to furnish the bond for the roof. In most cases, owing to lack of room, it was necessary to shelve under the railway conduit line. In such cases a rail was placed at the corner of the shelf to take part of the pressure of traffic on the manhole head. Short pieces of fiber duct were plugged and placed in walls wherever future outlets might be required.

In building the manholes and distribution holes enough space was left between the walls and parallel gas and water mains to allow joints to be recalked. Circular cast-iron manhole heads with single cover were used, having inside diameter of 36 in. for large holes and 30 in. for distribution holes. A film of cast iron (about 1/8 in.) was left over the locations of perforations when the covers were cast. In time the traffic punctures these thin coverings and the cover becomes truly "perforated." The manhole heads were set to the grade of the improved street from data given by the county engineer. Monolithic construction is disadvantageous if a head has to be lowered because of street improvement. In such a case the roof of the manhole must be destroyed and the rails let down into the walls the required distance.

No attempt was made to waterproof the manholes, as this is useless unless the conduit line is also waterproofed. Sewer connections were not provided for draining the manholes; instead the water is pumped out when it is necessary to work in them. A cavity is left in the floor of the manhole to facilitate the necessary pumping operations.

Fig. 2 is of interest, as it shows five different styles of underground conduit—fiber, single-tile, multiple-tile, "pump-log" and wrought-iron pipe.

Distribution Holes.—Rectangular monolithic concrete distribution holes 3 ft. by 4 ft., with 6 ft. clear depth, 8-in. walls and 6-in. roof and floor, were standard throughout the work. Three ducts of the main line were cut in for distribution purposes, the remaining six ducts being used for transmission work. In this case it was advisable to extend the

distribution hole down between the water main and the gas main in order to provide standing room for workmen.

When no cross-overs are used it may be advantageous to cut in the top layer of duct and use only a shallow hand hole for distribution. It was advisable to keep a side wall between the separated duct so as to avoid any possibility of puncturing the duct when installing expansion bolts for angle irons, etc., later.

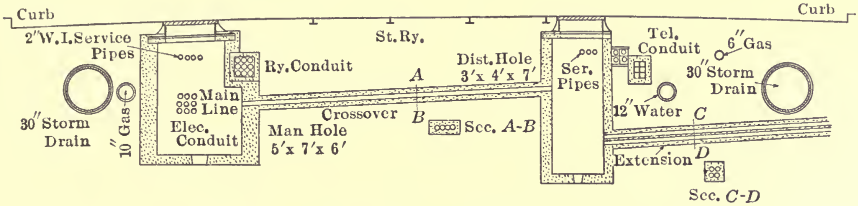


FIG. 2.—FIVE DIFFERENT STYLES OF UNDERGROUND CONDUIT.

Services.—For services 2-in. wrought-iron pipes were used, generally for three-wire distribution. For long services or where there were several bends to be made 2 1/2-in. pipes were employed. Care was taken in bending the pipes to avoid kinks, as the latter make drawing in of service wires difficult. Generally right-angle "machine bends" were used. A No. 10 steel "drawing-in" wire was left in each pipe of any considerable length or one having more than one bend.

COST DATA ON UNDERGROUND CONDUIT WORK

Time occupied, months	4
Average number men	40
Trench feet fiber conduit	9,802
Duct feet	75,700
Average cost per duct-foot (including Telford repaving, supervision and cost of duct)	$0.16
Service duct (wrought-iron pipe), feet	16,108
Cost of services per foot, average (includes cost of pipe)	$0.25
Distribution holes, 3 ft. by 4 ft. by 6 ft.	52
Manholes, 5 ft. by 7 ft. by 6 ft. and 6 ft. by 8 ft. by 6 ft.	39
Cost of distribution hole, average	$48.00
Cost of manhole, average	$152.00

After the service wires are drawn in, the end of the pipe should be cemented or plugged with oakum and compound to prevent gas entering the cellar from the manhole.

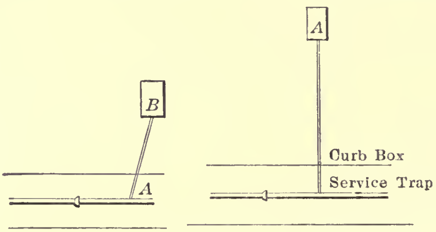
Where a street is to be improved and the ordinance prohibits tearing up the street pavement for a period of years it is advisable to run pipes inside the curb to vacant lots and buildings where electricity is not at present used. In cases such as these an arrow is chiseled in the curb or

sidewalk at the point where the service enters, the direction of the arrow indicating from which hole the pipe is run. With the aid of a record map and these marks a service can be readily "picked up." The service pipes were laid to drain into manholes or distribution holes.

In running services under patent concrete sidewalks it was convenient to use a trench jack or pipe jack to force the pipe from curb to cellar. This method saves time and leaves the sidewalk unharmed. In rocky soil, however, its advantages are doubtful, as a boulder will turn aside the steel nose screwed into the pipe, and the pipe will not strike the hole cut for it in the cellar wall.

In some cases because of obstacles semi-reamed-out couplings were used on bends, and when these are enveloped in cement mortar they are satisfactory.

Thawing Water-pipes with Electricity (By T. T. Logie).—The accompanying sketches show some results obtained by G. H. Caffrey, superintendent of the Norwalk division of the United Electric Light & Water Company in thawing pipes with electricity. An equipment consisting of a 15-kw. transformer, 2300-volt primary to 110-volt secondary and a water-barrel rheostat was used. The conductivity of the water in the barrel was increased by the addition of salt, about 10 lb. of salt to the barrel being sufficient. Labor expended in handling was reduced to a minimum by arranging the entire equipment on a wagon.



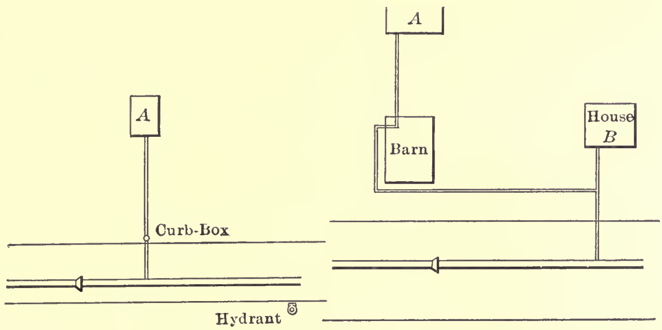
FIGS. 1 AND 2.—THAWING WATER PIPES WITH ELECTRICITY.

The service shown in Fig. 1 consists of 100 ft. of 1-in. pipe, laid on a grade of about 20 deg. To reach the street end of this pipe it was necessary to dig down to the main at a point marked *A* in the sketch. At this point one end of the secondary line was attached, which fed through to the point *B*, where the secondary circuit was closed. About 150 amp. at 60 volts was allowed to pass through this pipe for twenty-five minutes before water was obtained.

The conditions met with in the service represented by Fig. 2 differed from those above in that the length of pipe was double, the grade very slight and the pressure low. Connections were made in the secondary circuit at the point *A* and on the valve in the curb box, this latter connec-

tion being made by pushing down a hooked wire into the box and snapping the hook onto the wheel of the valve. From 100 amp. to 200 amp. at 60 volts was sent through this pipe without result other than heating the pipe. The main was then uncovered and the secondary connection removed from the curb box to the main. This resulted in water flowing within ten minutes, the frozen section being in the gooseneck trap which extended upward into frozen ground.

A third station differed from the foregoing in that a fire hydrant could be used in closing the secondary circuit. With another connection made at *A* and current passing through the pipe for two hours no water was obtained. A connection was then made on the curb-box valve by the method mentioned above, with the result that water flowed freely within five minutes.



FIGS. 3 AND 4.—THAWING WATER PIPES WITH ELECTRICITY.

The house shown in Fig. 4 receives its water from two sources, namely, the street main in front of the house and through a barn and a house service on an adjacent street. The service from the house marked *A* to the barn being free, it was a simple matter to thaw the remainder of the service from the barn to the house marked *B*, by making a connection in the barn and another under the sink in the house. Water flowed in this section after heating the pipe for four minutes. Another pipe leading upstairs was also frozen, but by transferring the barn connection of the secondary to the pipe upstairs it was cleared within two minutes.

Thawing Water-pipes without a Transformer (By L. N. Jones).—Sometimes a frozen water-pipe is to be thawed out in a place where no primary connection or transformer is available, or where it would be more expense and trouble to set up the transformer equipment than the single thawing job is worth. In such cases the method used by E. W. Erick, of Canby, Minn., may be useful, although a little more time is required to do the thawing than by the usual scheme.

In freezing several 3/4-in. service pipes in the winter Mr. Erick used the contents of the pipes themselves as water rheostats, making the exposed end of a No. 8 weatherproof-insulated wire act as one of the electrodes. As shown in Fig. 1, several rings of insulation were cut from the wire to expose its copper surface, while a rubber tip was attached to its end, serving to keep the metal from contact with the pipe which was connected to the other side of the line. Through the water path thus afforded 110 volts forced a current of from 15 amp. to 20 amp., delivering 1.5 kw. to 2.0 kw. near the front of the ice plug. In one instance 16 ft. of ice in a 3/4-in. pipe was thawed out in four and one-half hours, a boy being left to feed in the wire as the ice front retreated. The circuit was

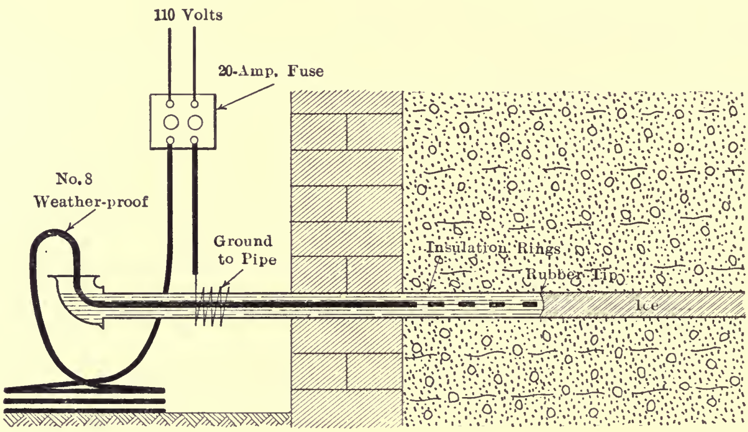


FIG. 1.—THAWING WATER PIPES WITHOUT A TRANSFORMER.

protected by a 20-amp. fuse, so that no damage could result from accidental short-circuit. This distance of frozen pipe was, of course, exceptional and was due to several days' delay in calling for assistance. As the water-rheostat method thaws at the rate of 3 ft. or 4 ft. an hour, only a short time is required to clear the usual foot or so of frozen plug. This scheme is applicable, of course, only to straight lines, but as most service pipes are included under this, the method will be found effective in most cases. The natural slope of the pipe toward the street drains the water toward the point where it forms the heat-producing path, but if the entry is quite level, a vertical elbow may be attached at the cellar end. In any case the street valve should be made ready to turn off the supply when the ice plug melts and the water comes with a rush.

One man can set up the simple apparatus needed to thaw pipes by this method, and a boy can feed in the wire after the operation is started. The expense of a line gang, transformer wagon and team and the usual

electrical apparatus are all avoided, and the trouble and danger of making primary connections are eliminated. Mr. Erick has ordered for future use a cartridge-type heating unit of a diameter small enough to be pushed into the pipe, and believes that this will prove more efficient than the simple electrode. To thaw the 16-ft. ice plug above mentioned, 8 kw.-hr. to 10 kw.-hr. was required, costing about $1 for energy, in addition to which was charged the time of one man.

Thawing a Frozen Pipe by Electricity (By Ch. Smeeth).—One winter the writer was called on to thaw out a 2-in. main in a distant part of a city. It was ascertained that a single-phase, 2300-volt line ran past the frozen main, and that a 30-kw. transformer was available. While looking around for some form of resistance or reactance it occurred to the writer that under the conditions nothing of this kind was needed and the following method was successfully carried out:

The line that ran past the frozen main was disconnected from the switchboard and connected to an idle alternator with an ammeter in circuit. The transformer was then hauled to the point where the pipe was frozen and connected up, the primaries being connected in the usual way and the secondaries spliced for their lowest voltage, which was 110 volts, and connected directly to the frozen main. The attendant at the power station was then communicated with and instructed to start up the alternator slowly (field excited) until the ammeter indicated 15 amp. It was expected that under the conditions the alternator would be running considerably under speed, but the attendant found that by keeping the exciting current low he could run at usual speed, thus keeping the frequency at its normal value. The primary voltage at the power house was 1800 volts. Twenty-four minutes sufficed to thaw the pipe, and this without reactances or resistances or trouble of any kind.

Methods of Soldering Wires in Terminal Lugs (By H. D. George).—Where many terminal lugs are to be soldered to conductors a convenient and time-saving method of making the connections is to melt a pot of solder over a plumber's furnace, pour the solder in the hole in the lug and then plunge the bared end of the conductor into it, as shown in Fig. 1. The insides of the holes of all commerical lugs are "tinned" so the solder adheres to them readily, and the bared end of the conductor should also first be tinned. This may be done as follows: The end of the wire is carefully scraped with a knife or a piece of fine sandpaper (the sandpaper is best because it cannot nick the wire) and then smeared with soldering flux and thrust into the solder pot. If a soldering stick is used the wire must be heated somewhat in the solder before the stick compound will melt and adhere. It requires but a fraction of a minute to "tin" the wire end in the pot. After removal the end should be knocked against some solid object to remove surplus solder. Immediately after the tinned end

is pushed into the hole in the lug the lug should be "soused" with a piece of wet waste to cool it rapidly. The job is finished by scraping or filing off any shreds or globules of solder that adhered to the exposed surfaces of the lug and by brightening it with fine sandpaper if necessary.

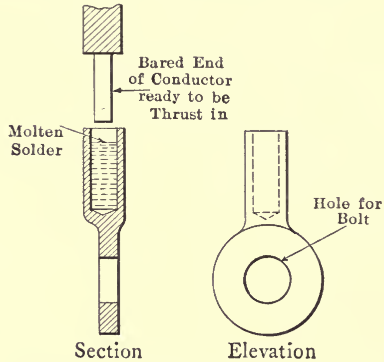


FIG. 1.—SOLDERING WIRE IN LUG.

The insulation from the conductor ends should be cut back just far enough so that it will abut against the shoulder of the lug, as suggested in Fig. 2, *A*. The appearance is very unsightly and indicates careless work if there is a gap between the shoulder and the insulation, as at *B*. If because of some mishap a connection does result, having the appearance

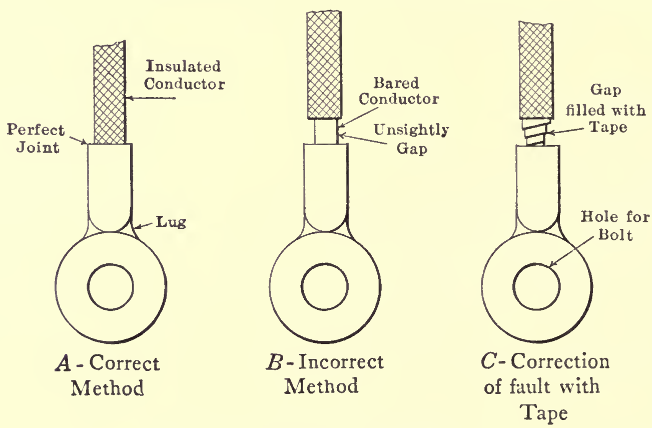


FIG. 2.—FINISHED CONNECTIONS.

of Fig. 2, *B*, a partial correction can be made by filling the gap with servings of tape, as shown at Fig. 2, *C*. The tape of the standard 7/8-in. width should be torn into strips about 1/4-in. wide before applying. Only enough molten solder should be poured into the hole in the lug to fill it almost to the brim when the conductor is in position. If too much

is poured in it will be squeezed out by the wire and will flow over the lug. It must then be removed at a sacrifice of time.

Another method of soldering wire in lugs is to heat the lug with a blow-torch flame, as outlined in Fig. 3. When the lug is sufficiently hot wire solder is fed into the hole. The solder melts and the bared conductor end is then thrust into it, as hereinbefore described. However, the use of a blow torch in this way should be avoided if possible, as it blackens the exposed surface of the lug. A thorough cleaning with fine sandpaper is then necessary, and that requires more time than is justifiable.

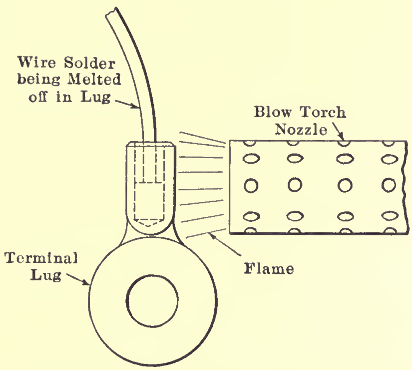


FIG. 3.—MAKING JOINT WITH BLOW TORCH AND SOLDER WIRE.

Soldered Wire Connections (By F. P. Kenney).—The method of soldering wires in terminal lugs as hereinbefore described by H. D. George may prove satisfactory in appearance to all and in stability to some, but others will agree that in few cases will it produce a first-class job. To secure proper adhesion between wire, solder and lug the temperature of all three must be above the melting point of solder at the instant of contact. If this condition does not exist nothing more than a good friction fit of all three parts will be secured; and if any doubt as to the truth of this exists in the mind of the reader let him apply a steady torsional strain to the wire or lug so secured.

While the use of a soldering pot as described is desirable, unless a method of heating both lug and wire be employed in conjunction, stability is sacrificed to speed and appearance. This is particularly true when the wire to which the terminal is to be soldered happens to be a "stranded conductor," wherein, to secure maximum mechanical strength and electrical conductivity, it is absolutely essential that the solder be maintained at the melting point until it has thoroughly permeated the interstices of the conductor.

It might be suggested that were the wire terminal and lug to be held in the molten solder until they had acquired a temperature equal to that

of the solder, the method described would be ideal. To prevent adhesion of solder to the outside of the lug it should first be dipped in a light oil of high flash point, being careful to see that no oil is permitted to reach the inside of the lug. It will be found advisable when holding the bared ends of heavy conductors in the solder pot to wrap the insulation well with a rag previously wrung out in cold water to prevent as far as possible the melting of the insulating compound and the consequent smearing of the terminal. However, any such drip will not impair the joint if properly made, though it will detract from the appearance of the finished job.

Soldering with Blow Torch and Iron (By C. Jennings).—When soldering connections between wires smaller than No. 8 many wiremen use a blow torch for heating the joint. While a joint can be made in this way, it is better to use a soldering copper where small wires are involved. Where a blow torch is used the insulation on the conductors is nearly always ignited and burns with a thick smoke and blackens any object on which it deposits. If the work is being done near a clean ceiling or side wall the result is a sooty spot near the point where each joint is made. It is probable also that the excessive heat of the blow torch injures the adjacent insulation of the conductors. Furthermore, the blow torch is difficult to manipulate in restricted locations. A small alcohol torch is sometimes used instead of a blow torch and is better adapted for the work, but it is probably not as good as a soldering iron.

In using a soldering copper it is heated in the flame of a blow torch. To solder the joint the hot tool is placed under and in close contact with it and wire solder is fed into the turns of the joint. After the solder has flowed over the entire surface of the joint the iron is removed and the joint is shaken to throw off surplus solder. There is no ignition of insulation and no sooty smoke where a joint is soldered in this way. The soldering copper can be used in confined spaces where the use of a torch would be out of the question. It is understood that the wires to be soldered must be scraped clean and bright before the tool is applied. Any of the commercial soldering fluxes will probably be found convenient as a flux.

Test-board Proof against Crosses or Shorts (By M. C. Rice).—On to the test terminals of the board shown 110-volt alternating current or 110-volt, 250-volt and 500-volt direct current can be thrown without any possibility of short-circuits or crosses between the several sources of supply due to manipulating improper switches. The three-way, double-pole knife switch is mounted on a pivoted turntable of switchboard marble, like the rest of the panel, and each jaw closes into a pair of contact clips, the hinge terminals being connected to the test clips as shown. Under no conditions, of course, can the switch be closed on to more than a single live circuit. This Fig. 1 also reveals means for getting one or both sides of the 250–500-volt three-wire system by manipulating the single-pole

knife switch at the top. The turntable switch scheme has a number of similar test-board applications, and while not difficult to construct, its use will be found to save much wiring complication besides insuring "foolproof" operation.

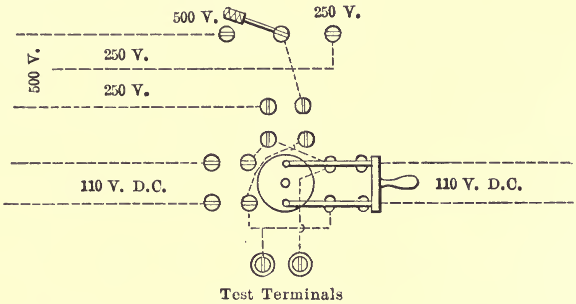


FIG. 1.—TEST-BOARD PROOF AGAINST CROSSES OR SHORTS.

Protecting Gas Pipes against Electrolysis (By J. L. Fitzhugh).—After a number of experiments in the effort to insulate and protect its service-pipe runs against electrolysis the Laclede Gas Company, of St. Louis, covers its wrought-iron piping with layers of pitch and paper, which seem successful in solving a vexatious problem. The wrought-iron pipe, in sizes from 2 in. to 3/4 in., is first coated with a tar-and-pitch mixture, heated and thinned sufficiently to flow easily, and onto this a 4-in. paper ribbon is wrapped spirally, its edges overlapping. This paper covering is then tar-painted and again wrapped with paper, the process being repeated until four successive coats of tar and paper have been applied. Pieces of pipe thus insulated have been placed

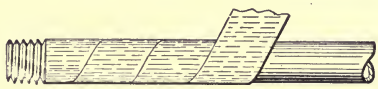


FIG. 1.—PROTECTING GAS PIPE AGAINST ELECTROLYSIS.

in the ground under the most distinctive conditions of electrolysis, along with other lengths not so treated. After being taken up at the end of two years the unprotected pipes were badly pitted and almost completely consumed, while the insulated piping was virtually in the same condition as when laid. It is believed that pipe so treated will have its life at least doubled, and if this is true an expenditure for insulation equal to that of the cost of the bare pipe is justified. Only service runs are being so treated, the cast-iron mains being less subject to corrosion and electrolysis than the service pipes. The tar and paper coating is very hard when cooled, and the pipe lengths need be handled with no more care than bare pipe.

The application to the pipe is shown in Fig. 1.

A Handy Portable Rheostat (By A. S. Johnson).—A handy pipe-frame wire-wound rheostat capable of very finely graduated adjustments and useful for many purposes, such as loading machines, discharging batteries, etc., is shown in the sketch (Fig. 1). The frame is made up of lengths of 2-in. iron pipe connected by the cross-piece and elbows, and firmly mounted on a wooden platform, which may be equipped with rollers to make the apparatus portable. Around the vertical pipes sheet asbestos is wrapped and on this is wound the resistor wire, in a single layer, care being taken to leave a slight air space between adjacent turns of the wire. In the cross-piece, half-way between the elbows, a hole is drilled to receive the vertical rod on which slides the movable contact, the lower end of the rod being firmly fixed in the platform. On this smoothed rod a rider is arranged to slide. This rider carries a pair

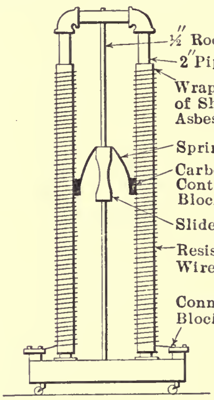


FIG. 1.—A HANDY PORTABLE RHEOSTAT.

of brass spring pieces ending in carbon blocks which bear flatly on the turns of the rheostat wire. The lower ends of the resistor coils are connected to binding posts on the platform base. When the slider is at the top of the rod all of the resistor is in circuit, and when dropped to the bottom the resistor is cut out. The friction and pressure of the springs on the coils hold the slider in position at any point desired. As the carbon contact blocks bridge several turns of the wire there is no sparking during the movement of the slider from one point to another. The vertical position of the resistor coils assists in dissipating the heat rapidly by a sort of chimney action and the margin of space around the bottom of the platform prevents the hot rheostat from being brought into contact with anything which could be damaged. Aside from these points the rheostat is inexpensive to build, and in serviceability will many times repay its cost. The resistor wire should be wound in opposite directions around each leg of the rheostat so as not to magnetize the pipe by the heavy currents flowing.

II

LINE CONSTRUCTION AND EQUIPMENT

Grounding, Methods of Erection and Identification, Records and Lightning Protection

A Method of Making Up a Ground Wire (By George L. Edgar).—Where a ground wire is to be connected to a pipe and no ground clamp is available the following method can be used: A length, possibly 3 ft., of the ground conductor is "skinned" and carefully scraped or cleaned with fine sandpaper. The pipe on which the connection is to be made is filed bright and clean for a distance of several inches and "tinned" if the connection is to be soldered. Then the bared end of the conductor is arranged, on the brightened portion of the ground pipe as indicated in

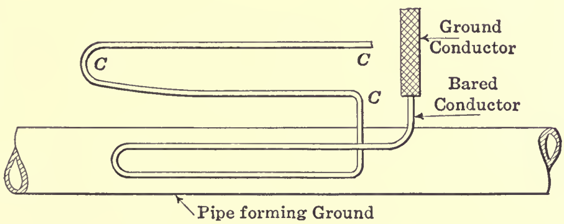


FIG. 1.

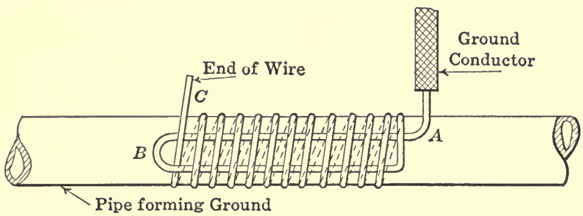


FIG. 2.

Fig. 1. The free end of the wire (*c*, *c*, *c*, Fig. 1) is then served around the pipe as suggested in Fig. 2, and the free end, *c*, of the wire is passed through the loop *B*. The end *A* is then pulled. This draws the loop *B* and the end *c* up tightly against the other turns and effectively prevents the wrapping from unwinding. In an actual connection the turns on the pipe are wound closely together. They are shown separated in Fig. 2 better to illustrate the method. The connection can be soldered with a blow torch

and wire solder using a paste flux or by pouring molten solder over the connection until it is hot enough for the solder to adhere. The soldering pot should be held under the connection during the pouring to catch the solder as it drops from the connection. Where soldering is not feasible the connection can be wrapped with a couple of layers of tinfoil and then with several layers of friction tape. These layers exclude moisture and prevent oxidation. The tinfoil and tape should extend along the pipe for several inches on each side of the connection and should be wrapped firmly to form a moisture-proof jacket A large telephone company has used the tinfoil and tape method on hundreds of ground connections for telephone subscribers' stations with excellent results.

Byllesby Companies Adopt Uniform Method of Grounding.—H. M. Byllesby & Company's method of grounding the secondary circuits of transformers where the potential of such circuits does not exceed 250 volts is as follows: All ground connections must be made at the poles where the transformers are installed and not within the building of the customer, nor shall the service switch either on the customer's side or on the service side be connected to ground. Secondary circuits over 1000 ft. long must be grounded every 1000 ft. The ground connection is made by driving a 3/4-in. galvanized iron pipe at least 5 ft. into the ground at the base of the pole, and more than 5 ft. if permanent moisture is not obtained at that depth. To the top of this pipe is secured, by means of babbitt metal poured into the pipe and extending therein 8 in., a piece of No. 6 gage BB

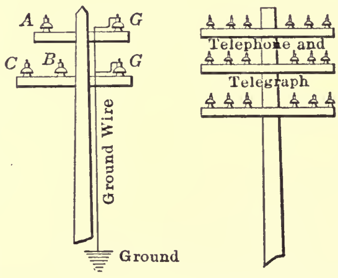


FIG. 1.—GROUND-WIRE SHIELDS TO PREVENT INDUCTION TROUBLES.

puddled iron wire. This connection is extended up the pole, the wire being secured by staples at intervals of 3 ft. For a distance of 7 ft. from the ground the ground wire is protected by a piece of heavy molding. All single-phase, two-wire secondary circuits are required to be connected to ground on one side of the circuit, and all secondary three-wire circuits are to be grounded at the neutral wire. All multiphase secondary circuits must be grounded from the neutral point of the phase connections.

Ground-wire Shields to Prevent Induction Trouble.—The accompanying Fig. 1 shows the transmission-line construction adopted at the

request of the owners of the telegraph and telephone lines, closely paralleling which a right-of-way had been secured for the 23,000-volt, 60-cycle circuit. The power-line delta was accordingly carried on the far side of the pole, the short-arm extensions on the telegraph side being used to support a couple of ground wires, one above the other, and each earthed

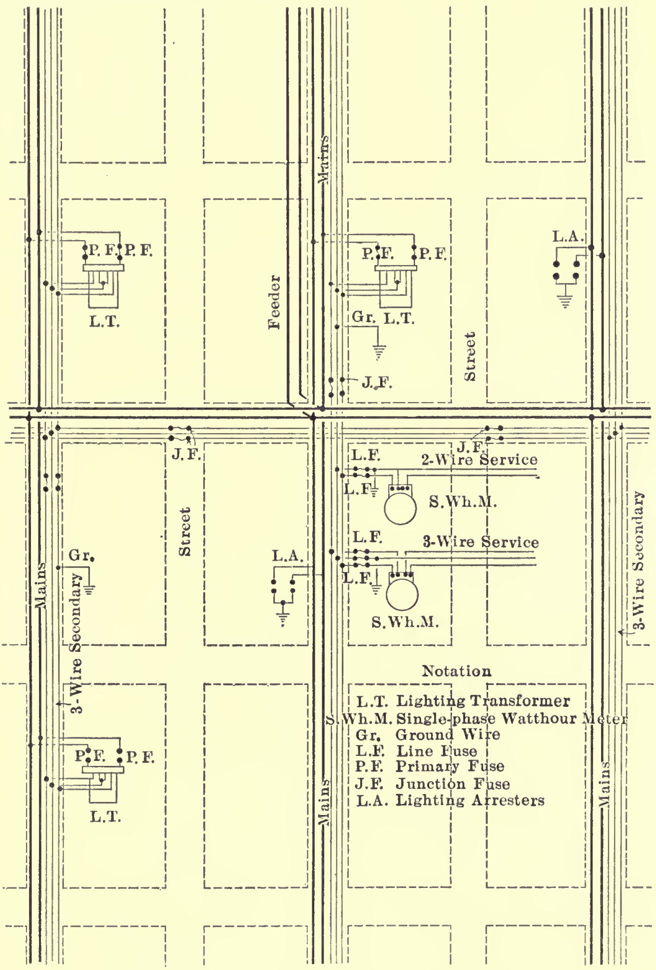


FIG. 1.—GROUNDING SECONDARIES AT DENVER.

securely at every seventh pole. Fear had originally been expressed concerning induction troubles on account of the nearness of the high-tension line, but after several years' operation no complaint has yet been made.

Grounding Secondaries at Denver.—Among the larger central-station systems which have adopted the grounding of secondary lighting networks

as a standard feature of distribution practice is the Denver Gas & Electric Light Company. The method is shown in Fig. 1.

The lighting service, which is of interest in connection with the grounding practice, is handled by multiple, single-phase, 2200-volt primary feeders and mains, supplying energy to secondary networks throughout the urban district through step-down transformers located at important centers of distribution and feeding individual consumers at 110 volts and 220 volts, according to the local load requirements.

The single-phase alternating-current system is made up of twenty-six two-wire, 2200-volt feeders extending from the station busbars to the electrical center of a definite section of the city which is electrically independent of any other section or feeder. The primary mains extend from the center of distribution in each section in the form of laterals or branches supplying energy to the most remote transformers of the district with the usual inclusion of intermediate transformers bunched, so far as practicable, to secure economy of operation and reasonable first cost. Any feeder may be fed from a special auxiliary bus in the station in case repairs, adjustments or inspection are necessary in connection with the switches and regulators in routine service. Within a given section the secondaries of all transformers are connected by three-wire tie lines forming low-tension busbars from which the leads to the various consumers are tapped. The transformers used on the lighting system vary in size from 1/2 kw. to 50 kw., and all above 1-kw. rating are connected for 2200 volts on the primary, each of the two secondary coils being brought out of the case and connected so as to give 110 volts between the middle or neutral line and either of the outside lines and 220 volts between outers. The company has found that with the load well balanced considerable saving in secondary copper results from this method of operation, as would obviously be anticipated.

Each transformer is connected to the primary main through outside-type primary fuses of double the transformer rating in amperes. The secondary network is sectionalized between each pair of transformers by a set of fuses or junction cut-outs, these being placed approximately at the point of zero current between the adjacent transformers on each secondary interfused section. The object of this fusing of secondary sections is to prevent the transformers on either side of a defective unit or secondary service from assuming heavy overloads. As soon as any abnormal conditions arise the junction fuses on either side of a defective section blow, as well as the primary fuses on the transformers, and the section is automatically cleared from the system. The junction fuses are of copper wire, being about 50 per cent. larger than the rating of the smaller of the two transformers between which they are in each instance placed, and varying from about 60 amp. between 5-kw. transformers to 400 amp. between 50-

kw. units. No fuses are installed in the neutral lines of the secondary networks, although fuses are placed in all leads running from any wire of the secondary service to consumers' premises.

The company began grounding in the residential district by connecting the neutral of the secondary mains to the nearest water hydrant at intervals of about two blocks. All services enter buildings in Denver from alleys at the rear, through which the primary and secondary mains are carried. The neutral-main ground connection is made by a No. 4 B. & S. copper wire stapled to the pole and covered with weatherproof insulation, the ground wire being run down the pole and to the hydrant at the bottom of a trench 18 in. deep. The alleys are 16 ft. wide and the neutrals are usually carried on 35-ft. poles about 20 ft. above the ground. Approximately 60 ft. of No. 4 wire is usually required for the ground connection in residence districts, the maximum length being 125 ft. The neutral ground wire is attached to the hydrant by the simple process of winding it beneath the footing bolt and making tight with a wrench. In the down-town section the usual length of ground wire required from the secondary network is from 10 ft. to 50 ft. The company has given up the use of the inclosed fuse in its secondary mains on account of the cheapness of open fuses. The total number of grounds made on hydrants by the fall of 1910 was about 150, the work being done with the consent of the Denver Union Water Company, which supplies water for domestic and commercial service within the city. From four to six hydrant grounds can be installed per day by a force of two men. In the residential district the average cost of making a ground was about $4.50, the cost of material coming to $2.50, with labor $2. In carrying out the work of grounding it was found necessary to put the current coils of all meters in the outer leads of the incoming service, in order to protect the company against loss of revenue from accidental grounds in the consumer's house-wiring. No evidence has been found of the disintegration of the hydrant grounds and no perceptible expense of maintenance has been found to exist in connection with the grounding system.

By regulation of the municipal authorities early in 1911 all new electric-lighting installations are required to ground their neutral wires, the owner and wiring contractor being responsible for this work. All wiring in new buildings is required to be in iron-armored conduit, and where possible concealed wiring in old buildings is required to be installed in this manner. The city requires conduit to be permanently and effectively grounded in such a manner that in case either wire comes in contact with the conduit and a ground exists on the opposite polarity it will be able to operate the heaviest fuse before burning off the ground. This ground is usually made by bonding the conduit to the water pipe. Grounding to steam or gas pipes is not allowed. An insulating joint and

canopy ring are required to insulate the fixture proper from the conduit. When fixtures or sockets are installed over cement or grounded floors, or in places where they can be reached from grounded parts of bathrooms, stoves, ranges, etc., porcelain sockets are required to insure safety while turning on the lights. The ground wire connecting the conduit with the water pipe cannot be smaller in circular mils than one-half the main feed wire. A special clamp is provided for grounding the neutral wire to the cabinet box and conduit system in the box, just inside the building in each case. The company's experience indicates that the grounding of lighting secondaries up to a point where the maximum potential between any lead and ground does not exceed 150 volts is an excellent precautionary measure.

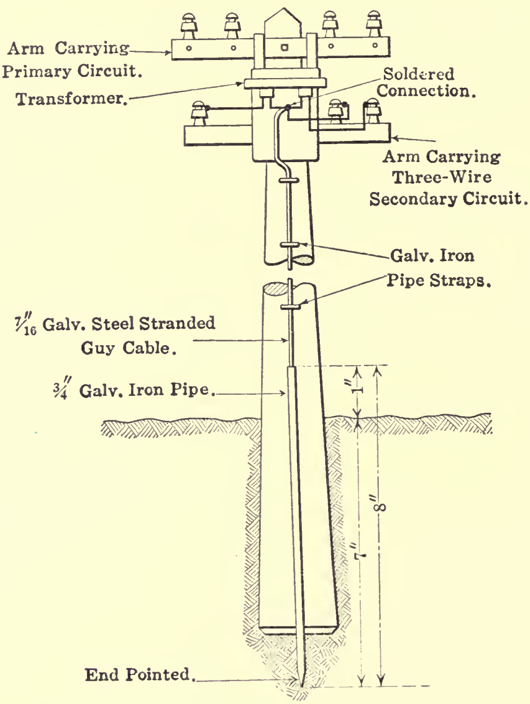


FIG. 1.—METHOD OF GROUNDING SECONDARY.

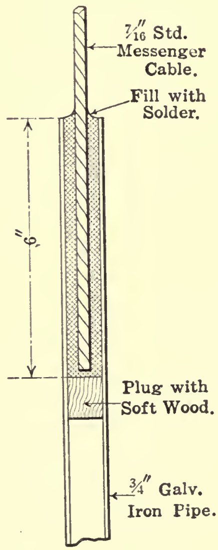


FIG. 2.—METHOD OF CONNECTING CABLE TO PIPE.

Methods of Grounding Transformer Secondaries and Secondary Networks (By Harold P. Jennings).—Ground connections can be made in many ways. They may be made inside of buildings by connecting to pipes or may be installed at the poles which support the transformers or the secondary networks. Central-station practice favors grounds at poles. Figs. 1 and 2 show the method of making a pole ground for aërial

secondaries used by the Allegheny County Light Company, of Pennsylvania. The lower end of the pipe is pointed, the upper end is "tinned" inside, and the wooden plug is inserted in the company's shop. In making a ground the pipe is driven into the earth next to the pole and the steel-cable ground conductor, its end having been tinned, is soldered into

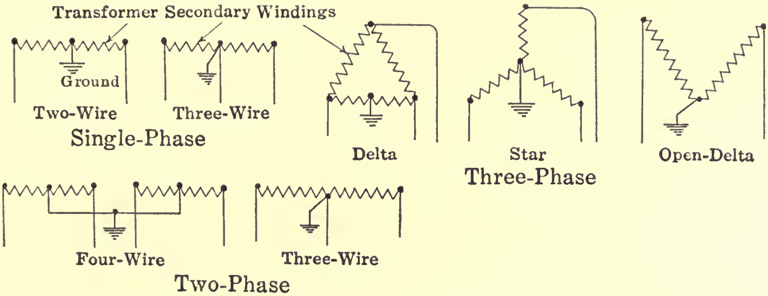


FIG. 3.—THEORETICAL DIAGRAM OF SECONDARY GROUND CONNECTIONS.

the upper end of the pipe by pouring molten solder in around it. An excellent feature of this method is that the 7/16-in. ground conductor is so strong that it will never be disturbed. It is secured to the pole with pipe straps.

The ground-pipe cap illustrated in Fig. 4 is used by several large

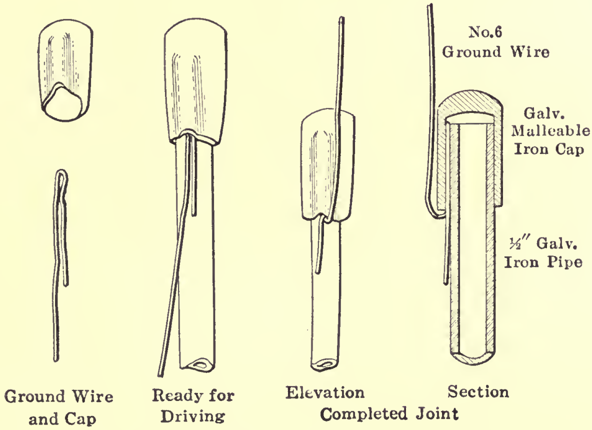


FIG. 4.—MAKING CONNECTION WITH GROUND-PIPE CAP.

central-station companies for connecting the ground wire to the ground pipe. Soldering is not necessary. The cap with the wire in position is placed over the top of the pipe and the pipe is driven. In driving the wire is firmly wedged between the cap and the pipe. The cap fits a 1/2-in. pipe or 3/4-in. rod, with a No. 6 ground wire. Where No. 4 wire is

used it is not necessary to double it. Ground pipes must be long enough to reach permanently moist soil, and in driving care must be taken not to drive them into the pole and thereby insulate them. Some companies ground to fire hydrants. The ground wire is supported down the pole by

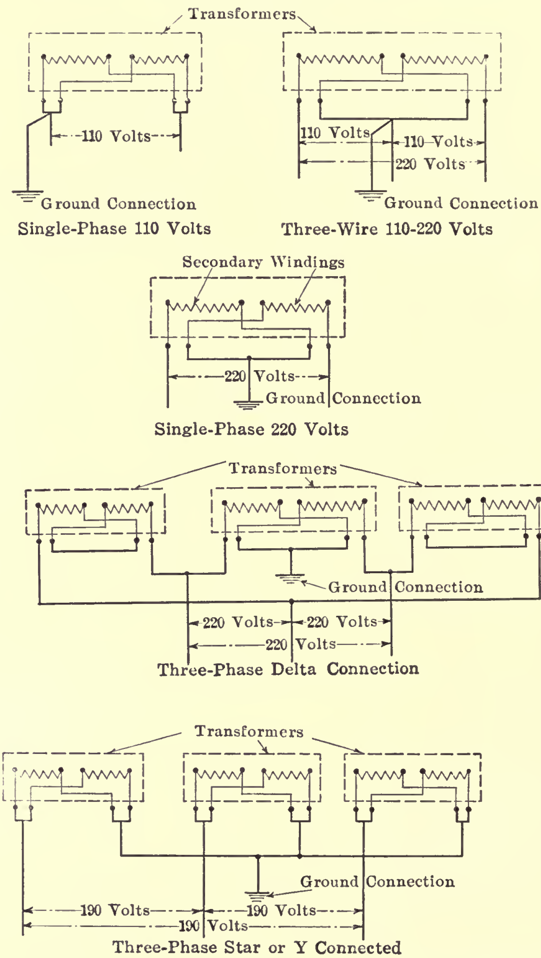


FIG. 5.—GROUND CONNECTIONS TO SECONDARIES OF COMMERCIAL TRANSFORMERS.

cleats or straps and is carried in a trench, possibly 18 in. deep, to the fire hydrant. It is connected thereto by clamping it under a footing bolt. In Denver this method costs $4.50 per ground, the average length of ground wire required from pole top to ground being 60 ft.

Ground wires should be incased by wooden molding for a distance of at least 7 ft. from the surface, to protect against shocks to passers-by.

Under certain conditions of soil moisture a shock can be received from a ground wire by a person standing on the earth's surface. The ground pipe extends about a foot above ground and is not usually protected. Some companies incase the entire length of the ground wire in molding to protect the linemen.

No wire smaller than No. 6 should be used for a ground wire, and some companies use nothing smaller than No. 4. Copper wire is preferable. Bare wire is satisfactory and should be attached to the poles with cleats or straps. Staples should not be used. The National Electrical Code requires for three-phase systems that the ground wire be of the same carrying capacity as any one of the three mains. There should be a ground for each transformer or group of transformers, and when transformers feed a network with a neutral wire there should in addition be a ground at least every 500 ft.

Ground-wire connections to transformer secondaries should be made to the neutral point or wire if one is accessible. Where no neutral point is accessible one side of the secondary circuit may be grounded, provided the maximum difference of potential between the grounded point and any other point in the circuit does not exceed 250 volts. Fig. 3 shows theoretical diagrams of ground connections to transformer secondaries, and Fig. 5 illustrates how some of these connections are arranged with commercial transformers. The neutral point of each transformer feeding a two-phase, four-wire secondary should be grounded, unless the motors taking energy from the secondary have interconnected windings. Where they are interconnected the center or neutral point of only one transformer is grounded. No primary windings are shown in Figs. 3 and 5. In Fig. 5 the secondary winding of each transformer is shown divided into two sections, as it is in commercial transformers.

Some Notes on Ground Connections (By E. H. Holmes).—It is quite well established that it is of the greatest importance that ground connections be well made. It has been the experience of men that have investigated lightning-arrester troubles that many are caused by imperfect earth connections. The best arrester equipment purchasable may be installed, but if the earth connection is not good the arrester cannot be expected to do its work properly. The cost of the earth connection is usually but a fraction of that of the arrester. Money spent in arranging a good earth connection is very well spent and it is just as important that a lightning arrester have a good ground as it is that the arrester itself be good.

In Fig. 1 is illustrated a good method of constructing a ground rod. It is one that has been used by telephone and electric-lighting companies to a considerable extent. The rod is of commercial rolled iron, and a diameter of 1/2 in. or 5/8 in. is usually chosen. Wrought-iron pipe,

either plain or galvanized, can be used instead of iron rod. A length of copper wire is soldered to the upper end of the rod, as indicated in Fig. 1, and the lower end is pointed. Such a rod should be from 5 ft. to 7 ft. long. It will be found most economical to solder the lengths of wire to the rods at the station, where the proper appliances usually are available. At best, it is not easy to solder to iron, so that for satisfactory results the operation should be performed under favorable conditions.

In soldering, the upper end of the rod should first be filed until it is quite clean and bright. All traces of scale and oil must be removed. Then it must be heated in the flame of a blow-torch until solder will melt when applied to it. The hot end should now be rubbed in a pile of

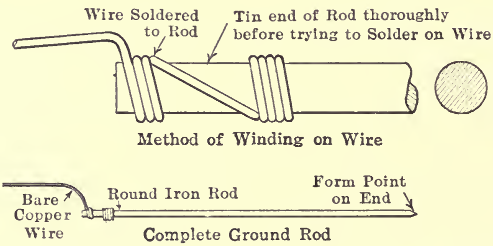


FIG. 1.—WROUGHT-IRON GROUND ROD.

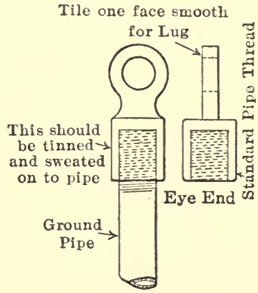


FIG. 2.—COMMERCIAL "EYE-END" ON PIPE.

powdered sal-ammoniac, which will clean it chemically, and solder wire should be applied simultaneously. The end will "take" the solder readily and soon become "tinned." The end of the length of copper wire can now, after being well cleaned with sandpaper, be wound around the tinned portion in the manner indicated in Fig. 1 and solder again applied. Solder will flow over the wire and effect a good electrical connection between it and the pipe or rod. The completed joint can be cooled quickly with a piece of wet waste.

Ground rods are installed by merely driving them into the earth. The ground wire from the lightning arrester or other device to be grounded is connected and well soldered to the length of copper attached to the ground rod. There is never much difficulty in soldering two pieces of copper wire together. When a ground rod is being driven the blows from the driving hammer tend to make it vibrate transversely. The effect of such vibrations is to push the earth away from the rod and to make the connection between them poor. Therefore, after driving it, the earth around a ground rod should be well tamped.

In the following table are shown some ground-rod resistance values—the resistance in ohms between driven ground rods and a town water-pipe system—which indicate the effect of thorough tamping.

Resistance before tamping	Resistance after tamping
1600 ohms	59 ohms
1800 ohms	83 ohms
1550 ohms	72 ohms
1950 ohms	90 ohms

These results are from some tests made on Long Island, New York. The formation was about 2 ft. of dark soil above a thick layer of sandy gravel. These resistance values, even after the ground had been tamped, are rather high. A good rod or pipe ground should, under favorable conditions, have not more than 15 ohms to 30 ohms resistance.

In Fig. 2 is illustrated a method of providing a pipe-ground rod with a terminal. The terminal is a commercial awning pipe fitting known as an "eye-end." This fitting is made in all standard pipe sizes from 1/4 in. to 1 in., inclusive, and is tapped with a standard pipe thread. This arrangement is convenient where it is desirable to disconnect the ground lead from the pipe so that the ground can be tested. A terminal lug should be soldered to the end of the ground lead. The lug is tightly bolted to the "eye-end." Then tinfoil is wrapped about the connection to exclude moisture and the whole thoroughly taped. A bolted connection, made as suggested, will remain in excellent condition for a surprisingly long time. It should, however, be inspected when the ground is tested. It is necessary to disconnect the lead from a ground pipe to test the ground resistance when the pipe forms one of a group, such as is used in a multiple-pipe ground. A diagram of a multiple-pipe ground is shown in Fig. 15.

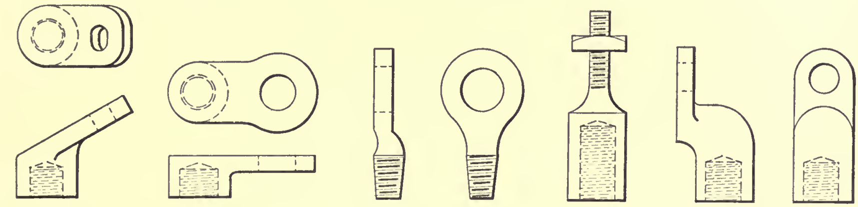


FIG. 3.—FORMS OF COMMERCIAL AWNING FITTINGS.

Other forms of awning fittings that sometimes can be utilized in arranging pipe grounds are shown in Fig. 3. All of these can be obtained in either black or galvanized finish, and all have standard pipe threads. The commercial name by which each fitting is known is given under it in the engraving.

In Fig. 4 is indicated the method of preparing a station ground for lightning arresters as recommended by one of the large electrical manufacturing companies. The ground plate is of sheet copper, tinned, and

should be about 1/32 in. thick. The ground wire, which should be equal in conductivity at least to No. 0 B. & S. gage wire, is soldered on the entire width of the plate. An old iron casting having a superficial area at least equal to that of the copper plate can be used if copper is not available. For a terminal a copper strap can be riveted to the plate. It is recommended that when the hole is being filled in plenty of water be used for settling the earth.

A great many grounds are made by the telephone companies for the telephone-station lightning arresters. Where possible a connection is

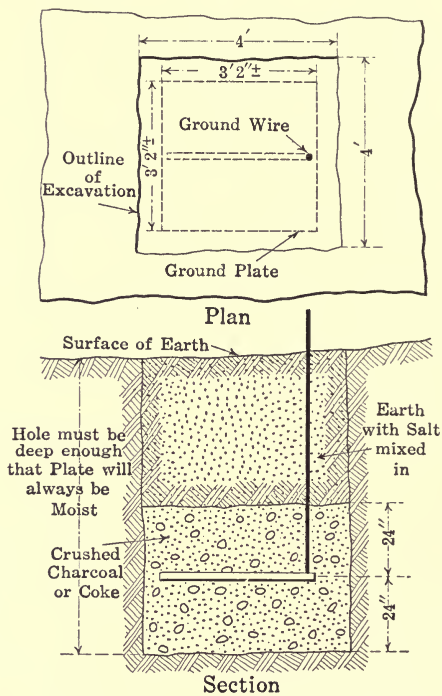


FIG. 4.—COPPER-PLATE GROUND.

made to a water or gas pipe with one of the many types of commercial ground clamps. In rural districts either ground rods or ground plates are used. Some companies use ground rods such as that shown in Fig. 1. Other companies prefer plates. Fig. 5 shows the ground plate used by one of the largest Eastern telephone companies. It is very much cheaper to install rods than plates because a rod can be driven into the ground in a few minutes, while it may take one hour or several to dig the hole for a ground plate. Plates like that of Fig. 5 are for telephone work, buried from 4 ft. to 6 ft. deep directly in the soil without any coke packing at the bottom of a hole.

Telephone central-office grounds must be good ones. As a rule, a connection is made to both gas and water pipes when the two are available. Fig. 6 shows the method of effecting a connection with a water

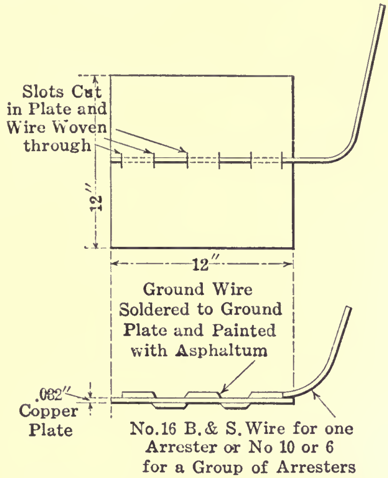


FIG. 5.—A COPPER GROUND PLATE.

pipe that has been used by some of the largest telephone companies. A special brass plug (see Fig. 7 for details) is turned into a tee in the pipe system and a terminal lug on the end of the ground lead is sweated and bolted to it. Such a connection is always made on the street side of the

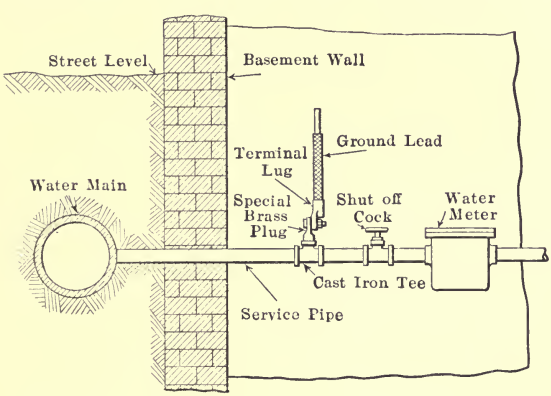


FIG. 6.—GROUND ON A WATER PIPE.

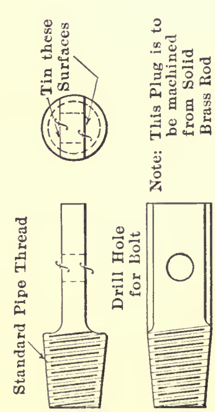


FIG. 7.—BRASS GROUND PLUG.

shut-off cock and of the meter so that the removal of either of these members cannot effect the continuity of the ground connection. Sometimes a connection to a water-pipe is made by soldering a copper strap around the pipe and then connecting the ground lead to the strap. It is extremely

difficult and not always altogether safe to solder to a pipe that is full of water.

Another form of ground that has been used by some of the big telephone companies is detailed in Figs. 8 and 9. A ground of this type is

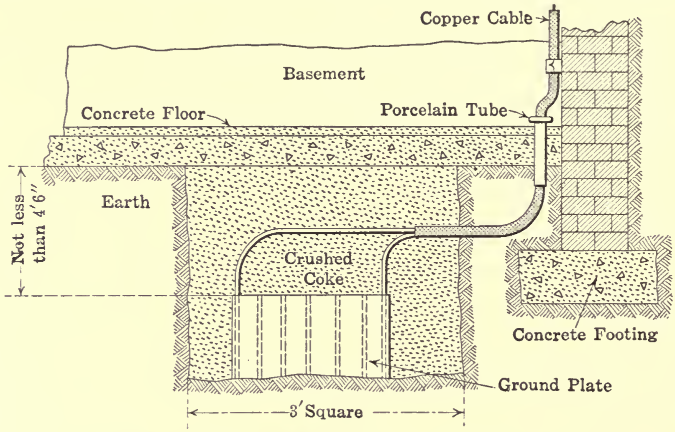


FIG. 8.—GROUND MADE WITH A COPPER SPIRAL.

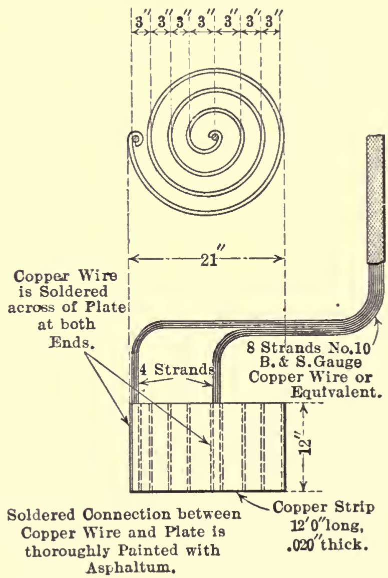


FIG. 9.—DETAILS OF A COPPER SPIRAL.

sometimes arranged under the basement floor of a central office, as shown in Fig. 8. This procedure appears to be satisfactory where there is every assurance that the earth surrounding the copper-ground spiral will always be moist. The writer has been given to understand that, even when this

type of ground is installed out of doors, a layer of concrete 1 ft. in thickness is placed at the surface over the spiral to maintain the ground lead in position and to prevent any tampering with the lead or with the copper spiral, which is shown in Fig. 9.

Common salt mixed with the earth surrounding a ground pipe or plate decreases the resistance of the ground much below that of a similar

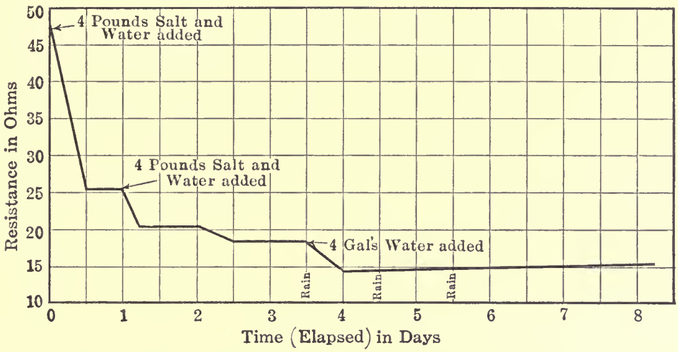


FIG. 10.—CURVE SHOWING EFFECT OF "SALTING."

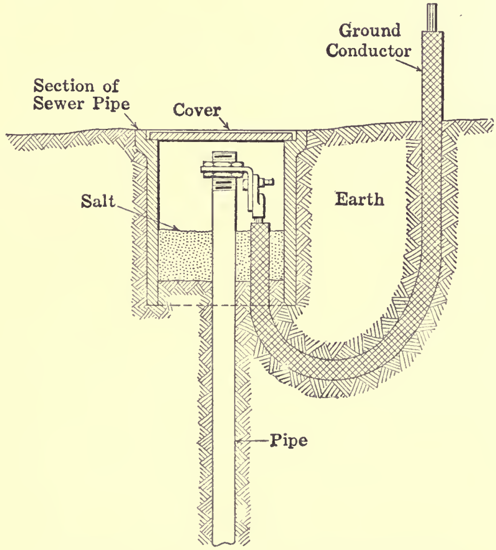


FIG. 11.—A "SALTED" PIPE GROUND UNIT.

but unsalted one. The curve reproduced in Fig. 10 brings out this fact. The ground from which the values plotted were obtained was made by driving a pipe 5 ft. into the earth. At the surface the soil was scooped out around the pipe. In this cup-shaped depression 4 lb. of salt was dumped. Salt and water were subsequently added as indicated on the

curve. It will be noted that the original resistance of the unsalted ground was about 48 ohms, but that it was reduced by the addition of salt and water to something less than 15 ohms. As the salt is washed out of the surrounding soil by rain the resistance of the ground will gradually increase.

To take advantage of the property of salt in decreasing ground resistance a form of pipe-ground unit similar to that shown in Fig. 11 has been suggested. A ground pipe having a nominal diameter of about 1 in. is driven into the earth a distance of about 6 ft. and a length of sewer pipe arranged around its top, as shown in Fig. 11. A wooden cover fits in the shoulder on the sewer pipe. The ground lead is connected to the pipe

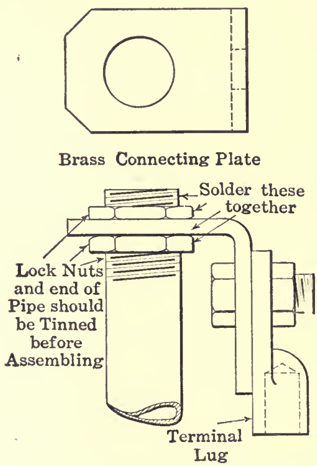


FIG. 12.—ONE METHOD OF CONNECTING TO GROUND PIPE.

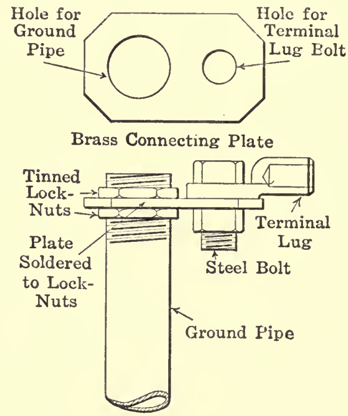


FIG. 13.—ANOTHER METHOD OF CONNECTION.

by means of the arrangement illustrated in Fig. 12. This permits the lead to be readily disconnected so that the ground may be tested. A supply of salt, which will soak into and saturate the surrounding earth, is maintained in the sewer-pipe chamber. Where the ground lead is not of heavy wire and can be easily bent, a simple connecting arrangement, outlined in Fig. 13, can be used. It can also be used where the ground lead leaves the pipe in a horizontal direction instead of in a vertical one, as in Fig. 11.

It was suggested above that the ground pipe should be driven to a depth of about 6 ft. Experiments show that little is to be gained by exceeding this depth. The resistance of a pipe ground does not vary inversely as the depth in a simple ratio. For the first few feet driven the resistance decreases rapidly for each additional foot of depth, but as the depth increases the resistance decrease is less rapid. The resistance is almost constant for depths greater than 7 ft. or 8 ft.

The practice of making multiple-pipe grounds is largely followed. A multiple-pipe ground (Fig. 15) consists of a number of pipe-ground units, similar possibly to that of Fig. 11, connected in parallel. The resistance of such a group is much less than that of any single unit in it. In arranging ground units one should be located as near as possible to the lightning

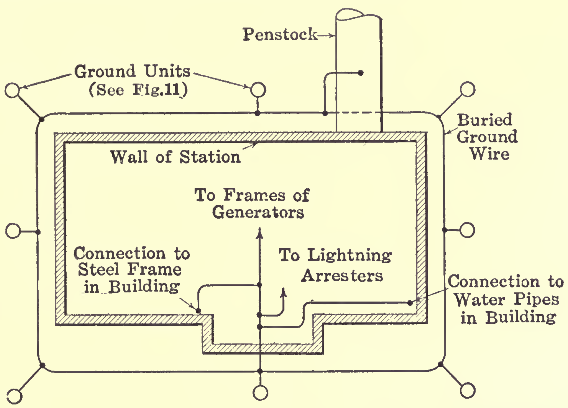


FIG. 14.— GROUND UNITS AROUND A GENERATING STATION.

arrester and the others grouped, as in Fig. 14, around the building. Auxiliary ground leads should be connected to the metal frame of the building, to any available water and gas pipes and to the penstock or pipe line if the plant is operated by water-power. Ground connections are also made to the frames and cases of apparatus to be protected.

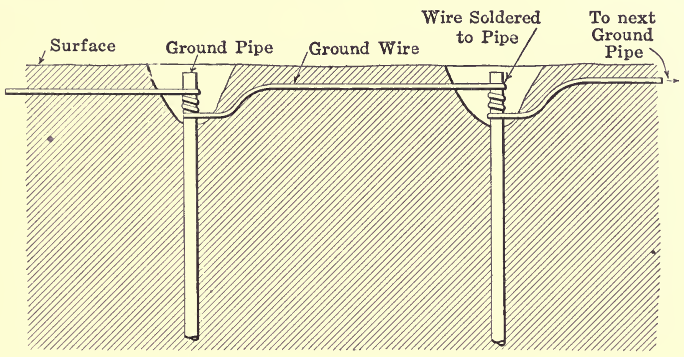


FIG. 15.—ONE METHOD OF MAKING MULTIPLE-PIPE GROUND CONNECTION.

A method of connecting multiple-pipe grounds together less elaborate than that illustrated in Figs. 12 and 13 is shown in Fig. 15. In this simple method the ends of the ground pipes are tinned, as described in connection with Fig. 1, before they are driven. After driving, the bare

copper ground wire that is to connect the pipe ends together is wrapped around each pipe in succession and soldered thereto.

Pole-height Estimator.—To insure accuracy in pole lengths the line department of The Milwaukee Electric Railway & Light Company is making use of a pole-height estimator, a pocket device originated by S. B. Way and J. L. Fay, of the company, with which an ordinary lineman can sight over the object to be crossed and read directly on a scale the pole required to give 5-ft. clearance when set in the ground to the proper depth. The estimator is similar in optical principle to the mariner's device for reading star ascensions, although simplified and arranged with scale calibrated directly in pole heights. To use the estimator, the lineman measures with tape or by pacing a distance of 50 ft. from the

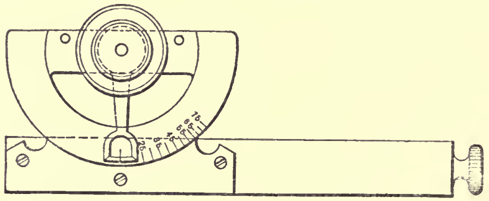


FIG. 1.—POLE HEIGHT ESTIMATOR.

point beneath the tree or obstacle, and then, from this distance, sights through the estimator tube at the tree-top or obstructing line. The turning of a knurled thumb-screw at the side rotates a level until its bubble, seen in a 45-deg. mirror, appears alongside the center of the tube. After bubble and object have been sighted together in the tube, the pointer shows on the calibrated scale the exact height of the pole, including clearance and setting allowances. Twenty-five-foot poles are provided to be set 4.5 ft. in the ground, 45-ft. poles 6 ft., and 75-ft. poles 7.5 ft., with proportionate amounts for intermediate heights. The estimators weigh only a few ounces and can be carried in the vest pocket. A drawing of an estimator is shown in Fig. 1.

Inspecting Inaccessible Places with Optical Aids (By J. L. Johnson).—To inspect insulators and line construction a pocket glass will save much climbing of poles or towers. A conductor down on the ground can be seen miles away across open country. An aid to estimating distances in this case is a pair of spiders' webs stretched across the field of view in the focal plane, the interval between the cross-hairs being made such as to subtend a man's height, say 6 ft., at a known distance—half a mile or a mile. A man, a house, a window or a door can be picked up in almost any landscape, and by this rough stadia method the distance can be approximately measured. The switchboard attendant will sometimes find binoculars useful in reading the instruments on a direct-current switch-

board across the room and at another level, ordinarily entailing a trip downstairs.

Battery Search-lantern for Linemen.—The overhead-line trouble department of the Topeka (Kan.) Edison Company makes good use of a battery-operated search-lantern when required to do night repair work. A regular 12-in. automobile search-lantern is employed with a 12-c.p., 6-volt tungsten lamp. The lantern is pivoted in the socket of the 3-ft. iron tripod which was built in a local blacksmith shop. With its double trunnions, the lantern can be turned and held in any position. A 60-amp.-hour ignition-type storage battery supplies energy through an 8-ft. length of flexible cord. This battery needs to be charged only two or three times a month and is always kept ready to be placed in the trouble wagon with the lantern for emergency use.

Trouble Man's Portable Search-lamp.—An acetylene gas tank and lamp of the type used by motorcyclists makes a valuable addition to the trouble-hunting kit of the Marion (Ind.) company's line department. For $2 a harness maker furnished a leather carrying case, enabling the tank to be strapped to the man's back out of his way. A flexible rubber hose connects the tank with the hand lamp. The complete equipment weighs only 12 lb. and costs but $10 to $16 for the tank, $4 for the lamp and $2 for the carrying harness. The tank can be exchanged for a freshly charged container at a very low cost. The carrying handle for the lamp can be hooked over the workman's belt if desired, or one man can be detailed to hold the lamp on the ground while the others complete the repairs. This outfit is especially valuable in locating pole trouble, fallen wires, etc.

Bucket for Bailing Pole Holes.—On running a pole line through territory which was rather swampy, considerable difficulty was found in keeping water out of the holes while they were being dug. The ordinary hand pump could not be used because the amount of water necessary to prime the pump was almost as much as the water in the hole, and it took a great deal of time to pump out. Mr. Schuster, of the Cosmopolitan Power Company, Chicago, in charge of the work, devised a little scheme which seems new. A heavy galvanized pail was taken and three flat valves from an ordinary hand pump were soldered in the bottom of the pail. All that is necessary to pump the water out of the hole is to push the pail down into the hole, which opens the valves, allowing the water to run in. The withdrawing of the pail closes the valves and the water can be emptied out.

Blasting Holes for Wooden Poles with Dynamite.—Nearly every central-station manager north of the Mason and Dixon line has had the unpleasant experience of paying prices ranging upward from $1 apiece for pole holes which had to be dug in frozen ground. The accompanying

illustration shows the scheme which was used by the Marion Light & Heating Company, of Marion, Ind., for digging holes when the ground was frozen to a depth of more than 24 in. The hole was first tapped and the earth removed to a depth of from 12 in. to 15 in., care being taken that the top of the hole was in conformity with the size of the finished hole

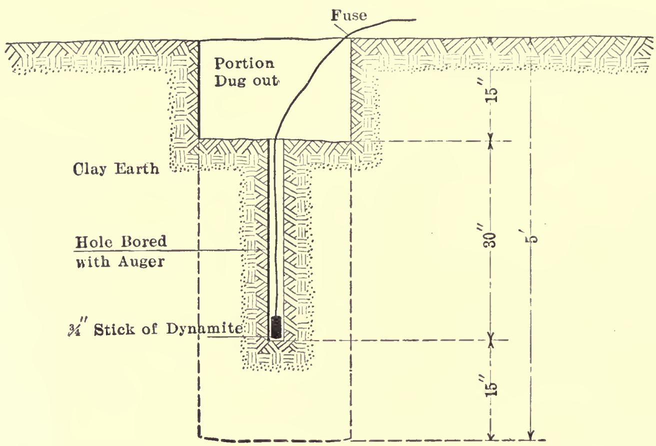


FIG. 1.—BLASTING HOLES FOR WOODEN POLES WITH DYNAMITE.

desired. A long-handled auger was then used to bore a hole slightly larger in diameter than a stick of dynamite to a depth of about 27 in. or 30 in. The charge, when placed in this small hole and tamped in and ignited, blew a neat round excavation as large in diameter as the portion which had been dug out at the top. With three-quarters of a stick of dynamite at the depth specified in the illustration, a hole 5 ft. deep was secured in the clay ground at an average saving of 15 to 20 per cent. over the cost of manual digging.

Numbering System for Pins and Cross-arms.—H. I. Ward, electrical engineer Muskogee (Okla.) Gas & Electric Company, has arranged a numbering scheme for his pins and cross-arms as follows: On all poles the pins on the top arm are numbered as "tens," those on the second arm as "twenties," third, "thirties," etc. On lines running north and south the poles are numbered from east to west, and on lines running east and west they are numbered from north to south. Six-pin arms are the standard although some four-pin arms are used. As single-phase and arc circuits precede in most extensions, these take the top arm. On all lines running north and south, single-phase primaries take the two east pins and are numbered 11 and 12. Since only one arc circuit wire is run on a pole line, except in special cases, the arc wire takes the pole pin on the

same side and same arm as the single-phase primaries, and is No. 13. Three-phase primaries take the second arm, pins Nos. 21, 22 and 23 being placed on the same side as the single-phase primaries. When single-phase three-wire and three-phase secondaries are run they take the opposite side of the pole and the same arm as the primaries feeding them. None of the pins are actually labeled, of course, the designation shown being simply memorized by the line workers. The same scheme is carried out on pole lines running east and west, all high-tension lines being placed on the north side of the poles. An application of this method is shown in Fig. 1.

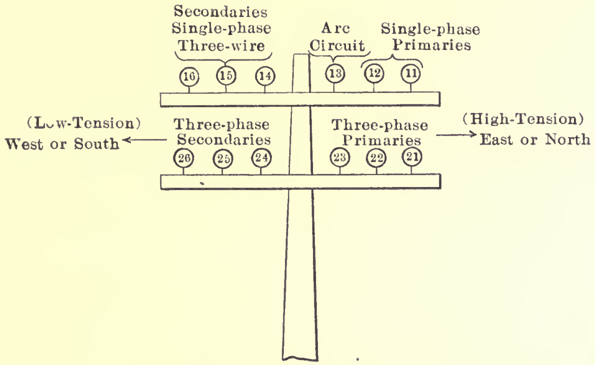


FIG. 1.—NUMBERING SYSTEM FOR PINS AND CROSS-ARMS.

Cross-arms made of Old Pipe.—On all new construction the Marion (Ind.) Light & Heating Company is making use of iron-pipe cross-arms. The second-hand 2-in. gas-pipe used is purchased at a junk value of 3 cents a foot and cut into 5-ft. cross-arm lengths. The metal pins are clamped to the pipe, standard wagon clips (costing 2 cents each complete with nuts) being fitted to the special galvanized pin castings produced locally for 3 cents each. The total cost of each pin is thus 5 cents. Holes are bored for the pole bolt and braces, at an estimated cost of 1/2 cent per pole, including handling. The brace holes are made 90 deg. from the pole bolt hole, and the braces are given a quarter turn at their arm ends so that they fit under the bolt heads. This is believed to give a neater and stronger brace construction, although it is not clear that such a quarter turn might not start a tendency to buckling of the brace. After the pipe cross-arm has been drilled and fitted, it is painted inside and out by dipping into a preservative color. Such pipe arms are expected to last twenty years or more, at the cost of a single wood arm, saving the labor cost of replacement.

When lines are to be dead-ended it is necessary to erect a double pipe-arm supporting the insulators from the top as well as the bottom. Ball strain insulators with stiff-wire jumpers may also be used. A color

scheme is used also to identify wires by the color of the corresponding insulator. Thus, arc lines are on light-yellow insulators while the 2300-volt primaries are carried on dark-brown insulators. The four-wire secondary circuits are mounted on white porcelain, and the ground wire is mounted on white porcelain insulators.

Replacing Insulators with 50,000-volt Line "Hot." (By L. R. Sloan).—With the aid of a special conductor clip which is fixed to the top of the glass pin-type insulators used to make temporary repairs on some of the 50,000-volt lines of the Butte Electric & Power Company in Montana,

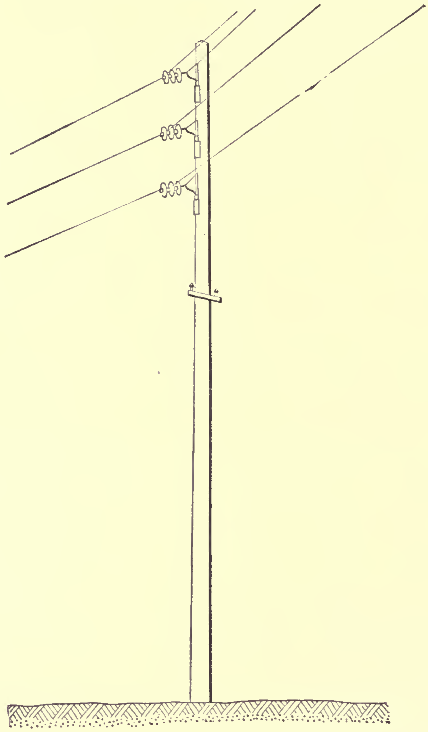


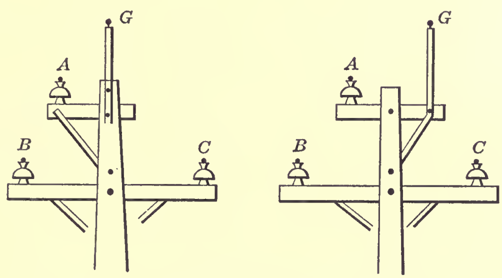
FIG. 1.—CORNER CONSTRUCTION ON 50,000-VOLT LINE IN MONTANA.

defective insulators are regularly replaced without "killing" the line. Climbing the pole, the lineman first adjusts a temporary strut support under the wire to keep it from falling on the cross-arm and then proceeds to smash the defective insulator off its pin with a long-handled hammer ing a 5-ft. shank. Holding the charged conductor out of the way, the new insulator is dropped into place on the pin. The wire is then lifted into the clip socket on the top of the insulator. This holds it fast against slipping off the insulator, although, of course, exerting no longitudinal grip on the conductor itself. The repair is effective, however, until the line

can be "killed" later to enable the lineman to tie in the insulator in the regular way.

Corner Construction for 50,000-volt Line.—The view, Fig. 1 on page 36, shows the unique corner construction developed by the engineers of the Butte Electric & Power Company's system for use on some of the company's 50,000-volt transmission lines in southern Montana. These angle turns are employed in conjunction with the standard wood-pole line using on tangent stretches two wood cross-arms and three-part suspension insulators. The upper cross-arm is then occupied by one conductor and the ground wire. For turns like that shown, all wires are brought into a single vertical plane and are supported from suspension insulators carried on special steel triangle brackets, requiring no cross-arms. The ground wire is carried around the outer side of the pole at turns, and the pole itself is properly guyed. This construction has now become standard for making all turns on the 50,000-volt lines of the Butte associated companies.

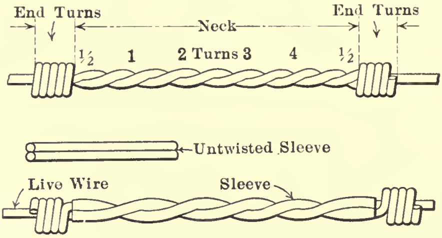
Combination Brace and Ground-wire Bayonet (By W. Llewellyn).—In the construction of a new transmission line entering Calgary, Alberta, Canada, a special fitting has been employed which takes the place of both the ordinary cross-arm brace and iron bayonet for ground-wire support, besides providing a balanced arrangement of the single-wire cross-arm.



FIGS. 1 AND 2.—COMBINATION BRACE AND GROUND-WIRE BAYONET.

Fig. 1 shows the original method used to carry the upper phase wire on a separately braced cross-arm, the ground-wire bayonet being bolted to the pole. This, of course, left the upper arm unbalanced. When the new transmission line was built, paralleling the first along the right-of-way of the Canadian Pacific Railroad, the construction shown in Fig. 2 was adopted. Here the brace and bayonet are made from a single bent piece of metal. The weight of the ground-wire approximates that of the phase-wire and serves to balance it, while the diagonal brace section of the support is required merely to preserve rigidity. Cost of material and work of installation are reduced.

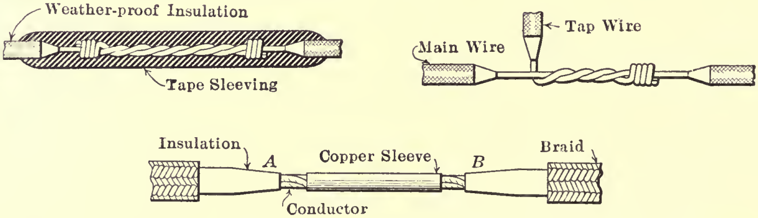
Methods of Splicing Wires and Cables (By H. V. Talbot).—Splices in bare copper line wire can be made as indicated in Fig. 1 and should be mechanically and electrically secure before solder is applied. There should be at least five turns in the neck (Fig. 1) of a splice to insure that the unsoldered splice will be as strong as the wire of which it is made. All splices in wires for conveying electricity should be soldered in the neck. It is not always necessary to solder the end turns. McIntire sleeves are



FIGS. 1 AND 2.—CONNECTIONS IN BARE WIRE.

very satisfactory and are used to a great extent for splicing aërial line wires. (See Fig. 2.) Solder is not necessary where sleeves are used.

Splices in insulated aërial line wires are made similarly to that shown in Fig. 1, except that tape is served around the splice for insulation. (See Fig. 3.) If the line wire has only weatherproof insulation, friction tape is sufficient, but if the inner insulation is rubber, rubber tape, to the thickness of the inner insulation, should be applied before the friction tape is served.

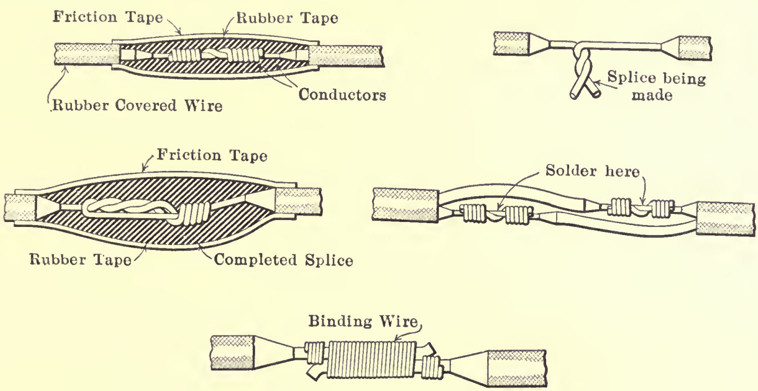


FIGS. 3, 4 AND 5.—CONNECTION IN WEATHERPROOF AND RUBBER-COVERED WIRE.

In preparing the conductor ends, about 1 in. of each end should be bared and cleaned; then, with a very sharp, thin-bladed knife, the insulation should be beveled for about 1 in. as one would sharpen a lead pencil. The conductor joint should preferably be made with a copper sleeve, sweating the latter on, care being taken to clean off all surplus solder, or if the connection is made by twisting the two ends together, that the ends do not protrude. The bevels and conductor should then be covered with a thin coat of a pure rubber cement, and this should be allowed to "set."

When insulating the joint a strip of 3/4-in. pure rubber tape 6 in. to 8 in. long should be wrapped spirally around the joint, beginning at the bevel on a level with the insulation (*A* in Fig. 5) and continuing to the other side of the joint as far as the high point of the bevel (*B* in Fig. 5). The operator should continue to wrap to and fro until the insulation is built up slightly thicker than the regular wall. The tape must be put on under tension—say stretched to about half its width, and care must be taken to have everything perfectly clean.

To vulcanize the joint partially heat may be applied evenly from a spirit lamp, a lighted match or the hand for about one minute. The joint may then be wrapped with two layers of 3/4-in. friction tape. If the wire is braided or taped, the braid or tape should be cut well back so that there are no loose threads overhanging to interfere with the proper insulation of the joint. Should the friction tape become slightly set, as it sometimes does in extreme cold weather, a gentle heat will restore it.

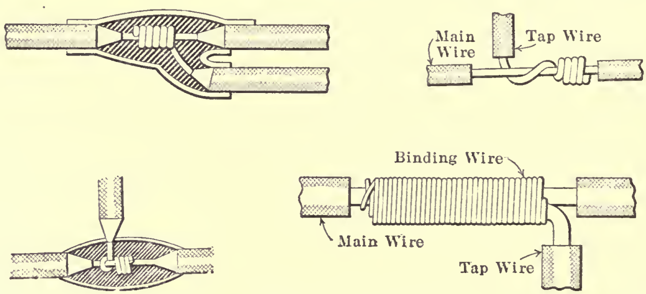


FIGS. 6, 7, 8, 9 AND 10.—SPLICES IN INTERIOR WIRING.

Splices in interior wires are made as shown in Figs. 6, 7, 8, 9 and 10. Not as many turns are necessary in the neck as for aërial line wires, and all splices must be soldered. Rubber tape to the thickness of the rubber insulation must be used on rubber-covered wires and friction tape must be served over the rubber to hold it in place. The so-called "fixture splice" (Figs. 7 and 8) is used largely by telephone men and in wiring fixtures. It can be conveniently used sometimes in splicing two wires that must be drawn taut in the splicing. A splice in wires is often made at a point between two supports (cleats or knobs) in this way. The duplex wire splice (Fig. 9) is often used by telephone men. The joints should always be "broken"; that is, they should not be opposite each other. In conduit work where duplex wire is frequently used joints are not permitted by the National Electrical Code except in junction boxes, but nevertheless they are occasionally made as indicated and pulled into the conduit.

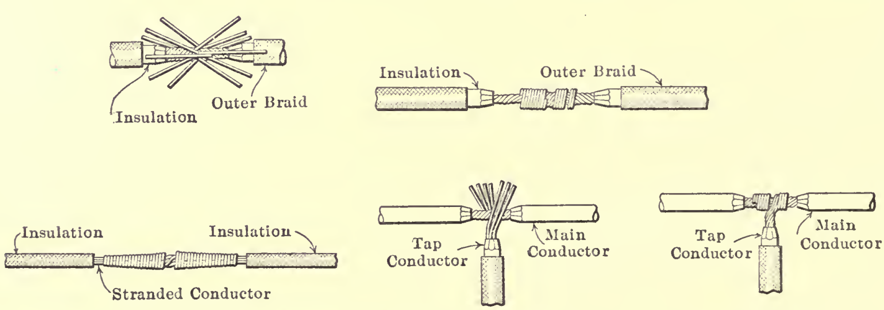
Rubber and friction tape are applied to each in the same way as to the joint in a single wire, and then the pair of wires should be served with friction tape. Joints should always be taped so that the insulation over the joint equals that over the rest of the conductor.

Taps in interior wires are made as shown in Figs. 11 and 13. The "knotted" tap has the advantage that the tap wire cannot untwist from



FIGS. 11, 12, 13 AND 14.—METHOD OF MAKING TAPS OFF MAIN-LINE WIRE.

the main wire. Tape should be applied as in the case of splices. The tap for small aërial wires (Fig. 4) is made by giving the tap wire one long complete wrap around the main wire and then four short turns. Taps for larger aërial wires can be made as suggested in Fig. 12. The long wrap gives the joint a certain amount of flexibility which is necessary for aërial work where the wires are moved by the wind. The tap for very



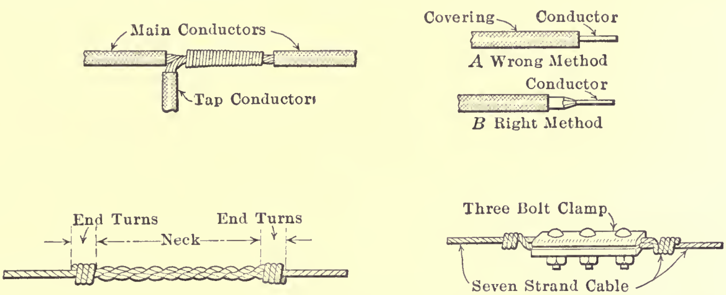
FIGS. 15, 16, 17, 18 AND 19.—METHODS OF MAKING SPLICES AND TAPS IN STRANDED CONDUCTORS.

large wires (Fig. 14) is made by serving a binding wire about bared portions of the tap and main wires and then soldering the whole.

Joints in cables are made as shown in Figs. 15, 16 and 17. The wires composing the cable should be spread and each pulled out straight and the core or a few inner wires cut away so that the splice will not be bulky. Then the two cable ends should be abutted as shown in Fig. 15, and the wires interwoven in groups of two each and served along the cable. The

joint is soldered by pouring, with a ladle, molten solder through and over it. For interior work a short joint like that of Fig. 16 is frequently used, but in aërial work a longer one, like that of Fig. 17, is preferred. For an aërial joint (Fig. 17) a length of about 16 in. to 20 in. is bared at the end of each cable in order to make a splice.

Taps in cables are made as suggested in Figs. 18, 19 and 20. Fig. 18 shows how the tap wires are "fanned" out before being served about the main conductor, and Fig. 19 shows a completed tap joint for interior work. Fig. 20 shows a completed tap joint in an aërial cable. Tap joints in cables can be made with a binding wire similarly to the method of



FIGS. 20, 21, 22 AND 23.—JOINTS IN HEAVY CONDUCTORS AND STEEL CABLES—METHODS OF REMOVING INSULATION.

Fig. 14. When a joint like that of either Fig. 19 or Fig. 20 is made the entire core or some wires should be cut from the center of cable so that the joint will not be bulky.

In making any joint the wire ends should be scraped bright with the back of a knife blade, sandpaper or emery paper, so that the solder will adhere readily. Insulation should be cut away as shown at *B* (Fig. 21) rather than as shows at *A*. When cut as at *A* the wire is likely to be nicked and with the *B* method the tape can be served more neatly about the joint. The outer braid should be cut well back from the joint so that stray strands from it cannot be taped into the joint and, by capillary attraction, conduct moisture thereto.

For soldering joints a non-corrosive fluid is recommended; solutions made with acids should be avoided. The commercial soldering pastes and sticks give good satisfaction in cleaning joints to be soldered. Joints in small wires are best soldered with a soldering copper, and burning of the insulation is thereby avoided. An alcohol or a gasoline torch should be used on medium-sized joints, while on the larger ones it is most convenient to employ a solder pot and ladle.

A soldering flux removes and prevents the formation of an oxide during the operation of soldering, so that the solder will flow readily and unite firmly the members to be joined. For copper wires the following solu-

tion is recommended by the Underwriters: Saturated solution of zinc chloride, five parts; alcohol, four parts, and glycerine, one part.

Soldering paste or stick can be made as follows: Melt 1 lb. of tallow and add 1 lb. of common olive oil; stir in 8 oz. of powdered rosin; let this boil up and when partially cool add, stirring constantly, 1/4 pint of water that has been saturated with powdered sal-ammoniac. Stir the mixture constantly until cool. By adding more rosin it can be cast into sticks.

Galvanized iron or steel wires are spliced as shown in Fig. 1, and five turns are necessary in the neck of the splice to insure that the splice shall be as strong as the wire. The strength of an unsoldered joint is determined by the number of turns in the neck, the end turns having but little holding power.

Small galvanized steel cables are joined in the same way as are wires, as shown in Fig. 22. There should be five turns in the neck, as with wires, and a few end turns to finish off the joint. Soldering is unnecessary for guy wires. Larger cables can be spliced as shown in Figs. 15 and 17, or mechanical clamps can be used instead, as shown in Fig. 23. Sometimes it is necessary to use several clamps, instead of one, as the figure shows, in order that the joint may be as strong as the wire.

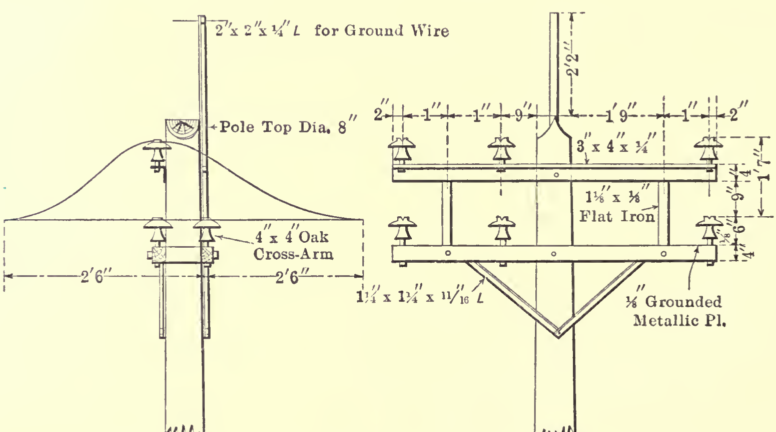


FIG. 1.—HIGH-TENSION CROSSING WITH PROTECTIVE LOOP.

High-tension Crossing Construction with Protective Loop.—In the sketch (Fig. 1) is shown the 6600-volt overhead crossing construction adopted by the Dayton Power & Light Company, of Dayton, Ohio. This design adheres generally to standard specifications but has the added safeguard of an extra loop passing over a pin-type insulator on the upper cross-arm. As initially contructed this loop is free of all other tension than that imposed by its own weight, but if an insulator of the crossing span breaks the upper insulator at once comes into play to sup-

port the line both mechanically and electrically. This eliminates possibility of the power line falling and endangering lives.

For railroad crossings this extra-loop construction is employed on the poles at each end of the 90-ft. crossing span. A minimum height of 30 ft. is imposed from track rails to the lowest wire. The adjacent 135-ft. spans are also double guyed with 5/16-in. stranded-steel cable, each pole top being tied to the adjoining pole butt. For a single-circuit, three-phase line, as shown, all conductors are mounted in the same horizontal plane on four-pin arms. The lower arm is of 4-in. by 4-in. oak, capped with a 1/8-in. metallic ground plate, while the upper arm, on which the emergency loop insulators are mounted, is of 3-in. by 4-in. by 0.25-in. angle section. Anchoring the upper arm rigidly to the lower is a pair of vertical, flat 1.125-in. by 0.25-in. braces, which also serve as ground connections.

Another form of crossing construction reported from Ohio by the electrical transmission committee of the Ohio Electric Light Association involves a reversed catenary arrangement. The regular catenary construction—that is, a suspension cable with loops down to support the feed wire—was considered objectionable, because some difference of potential through leaks might set up rapid depreciation.

The plan adopted was the extension of the main feeder straight through over the crossings the same as in the other part of the line (except for the addition of the double arming on either side of the crossing) and on this main feeder over the space to be protected loops were connected permanently to the main line every 5 ft. The loop wire was of the same size copper as the feeder. The loops were allowed to extend down about 4 in. below the feeder, then through these loops another copper wire of the same size and capacity as the feeder was run. This wire was allowed to hang free in the loops, and extended to and beyond the insulator supporting the feeder on either side of the space to be protected, where the free wire is connected to the feeder with a good soldered joint. Should the feeder break from any cause the free wire will then support the feeder and prevent it from coming down or doing any damage to the crossing, while at the same time continuity of service will be unimpaired.

Simple Method of Transposing Wires (By P. F. Larned).—Fig. 1 shows a scheme of transposing a pair of telephone wires at every pole of the transmission line along which they are carried. This is certainly so simple as to have deserved better attention from engineers who design lines and use instead the unsatisfactory double-groove transposition insulator or four-insulator construction. The method consists in rotating the circuit by crossing wires between poles, allowing the lower wire several feet more sag than the other. In a line carried on pins 3 ft. apart and hung in 600-ft. spans, 3 ft. difference in the sags of the crossing wires has proved an entirely satisfactory and permanent construction. The wires

cannot swing together and make contact, for at the middle of the span, where the tendency to swing is greatest, the wires are correspondingly most widely separated. In a line of any length the unsymmetrical suspension of the wires is compensated since each wire occupies alternately the long and short sag position. The only provision to be made in using this construction is that the wires do not slip on the insulators or the latter rotate under the unbalancing action of the unequal spans, letting the wires get together.

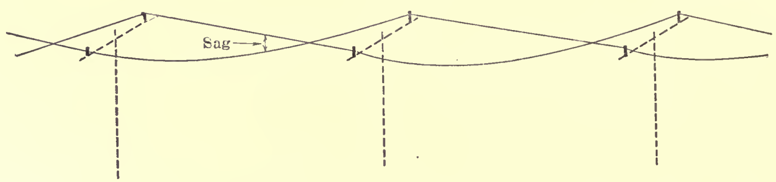


FIG. 1.—SIMPLE METHOD OF TRANSPOSING WIRES.

Use of Choke Coils with Pole Arresters (By L. F. Bradley).—Choke coils are inserted in the 2300-volt lines of the San Antonio (Tex.) Gas & Electric Company (Fig. 1) on the station side of each lightning arrester to divert abnormal discharges and surges into the ground paths and away from the adjoining sections of the line. These choke coils are made up of twenty-eight turns of the regular line conductor wound with an 8-in. internal diameter, the wire being pyramided so that the coils are triangular in section. The whole is then tightly wrapped with tape and mounted from a glass insulator on a bracket pin extending from the cross-arm. On

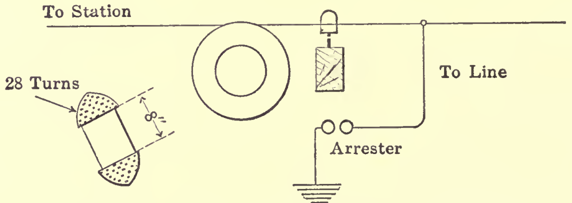


FIG. 1.—CHOKE COIL INSERTED IN 2300-VOLT TRANSMISSION LINE.

the longer runs these choke coils are inserted at intervals of about 1 mile or wherever arresters are installed. Similar coils are installed at the underground cable entries of all overhead lines. More than fifty of these coils were in use on the San Antonio lines in May, 1912, and since they were put in lightning troubles have noticeably decreased, according to G. B. Cushman, electrical superintendent of the company. Occasionally a coil is burned out, but when this happens it can be easily replaced.

Adaptation of Three-phase Arrester for Two-phase Use.—In purchasing lightning-arrester equipment for some two-phase circuits in

several Kansas City substations which were likely to be changed to three-phase operation shortly, standard three-phase, 2300-volt aluminum-cell arresters were selected and adapted temporarily to two-phase operation as shown. For this two-phase protection the three-phase equipment, it will be noted, required only four elements instead of the six generally furnished. By the use of the connections shown both arresters are charged from a single phase, only one of the second-phase terminals being led to the arrester. This unconnected side and the corresponding side of the first phase are equipped with feeder regulators, the static arresters of which afford ample protection.

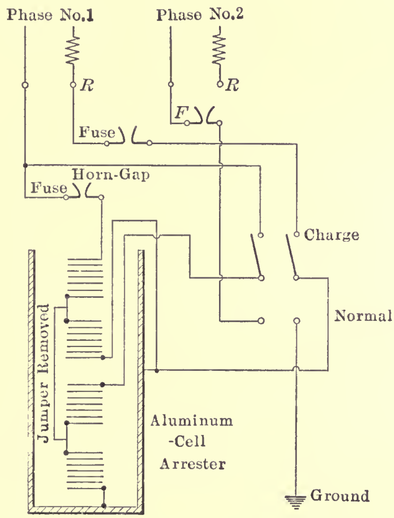


FIG. 1.—ADAPTATION OF THREE-PHASE ARRESTER FOR TWO-PHASE USE.

As furnished by the manufacturer, the arrester comprised four groups of elements connected to a common point, with the far side of one of the groups grounded onto the cell. By removing one jumper the various group taps were made available for two-phase operation. With the charging-switch blades in the lower position both phases are connected through the cell to earth. With the switch up energy is taken from the first phase for charging both sets of arrester elements. This arrangement was devised by R. K. McMaster, electrical engineer of the Kansas City Electric Light Company.

Maintenance of Electrolytic Arresters (By W. W. McCullough).—The value of the aluminum-cell electrolytic lightning arrester depends upon the proper maintenance of the film on the surface of the plates making up the arrester. The maintenance of this film depends, first, on the temperature of the electrolyte, and, second, on the frequency of "flash-

ing" or "charging." The operation of electrolytic arresters, given proper "charging," presents very little difficulty in climates where the electrolyte is not subjected for long periods of time to high temperatures. In semi-tropical countries with the arrester tanks exposed to the sun, however, it is extremely hard to keep up the film on the plates, only a few hours being sufficient to dissolve the film immersed in the warm electrolyte. This trouble has been remedied to a large extent on a 60,000-volt system in Florida by painting the arrester tanks white instead of black as originally furnished, advantage being taken of the increased heat-reflecting qualities of a white surface as compared with a black one.

Emergency Strain Insulators Made from Glass Insulators (By H. L. Beardsley).—A strain insulator that gives entirely satisfactory service when used with ordinary good judgment can be made, as indicated in

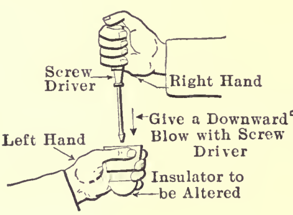


FIG. 1.—METHOD OF ALTERING INSULATOR.

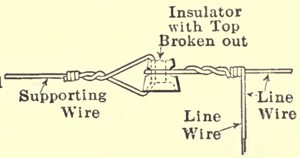


FIG. 2.—ALTERED INSULATOR IN USE.

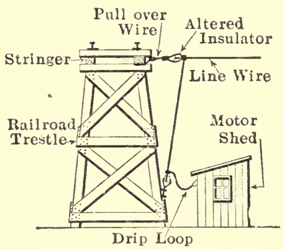


FIG. 3.—LINE WIRING FOR A MOTOR.

Fig. 1, by knocking the end out of a commercial glass insulator. Obviously a strain insulator made in this way is not as good either mechanically or electrically as many standard types that are readily obtainable. It is recommended only for emergencies or temporary installations. Some applications are shown in Figs. 2 to 7.

Any heavy tool having a portion of suitable diameter and long enough to reach and enter the bottom of the glass insulator may be used for altering the insulator instead of the screw-driver shown in Fig. 1. The insulator to be altered is held with the left hand and with the tool a sharp downward blow is given into the threaded cavity of the insulator and against the bottom. Occasionally the insulator will break into many pieces and be lost, but usually only its top is cracked off on a reasonably regular plane. Linemen use their connectors or their pliers in altering insulators. The blow is given with one of the legs or sides of either of the tools.

Fig. 2 shows one of the many methods of making up the wires about an altered glass insulator. In the illustration the line wire is shown in the groove and the supporting or pull-over wire is shown threading through the hole. This arrangement need not necessarily be followed.

The relative locations of the two wires are often made the opposite of those shown. In Fig. 3 an application is shown of the combination detailed in Fig. 2. A motor had been installed for a contractor's plant in a shed (Fig. 3) which was close to a railway trestle. It was imperative that the motor should be connected immediately to conductors on a pole line a short distance, possibly 150 ft., away. Wire and insulators were available, but no other electrical material and it was desirable so to make

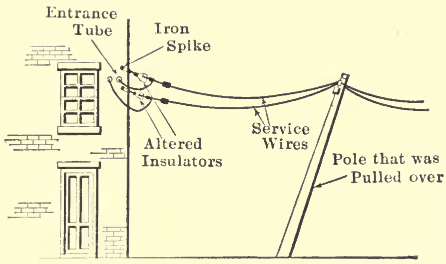


FIG. 4.—AN EMERGENCY APPLICATION OF ALTERED INSULATOR.

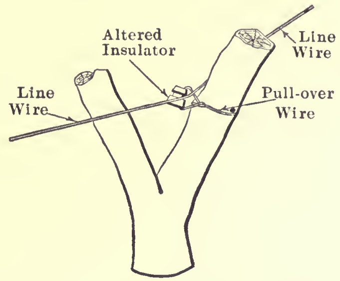


FIG. 5.—AN IMPROVISED TREE INSULATOR.

the installation that it would be reliable and capable of operating for several months. The outside wiring was insulated and supported with altered insulators as suggested in Fig. 3.

Another emergency application is shown in Fig. 4. In this case altered insulators were used to restore electric lighting service to a building. When the electric lighting company's emergency man arrived at the building he found that the pole from which the service wires to the

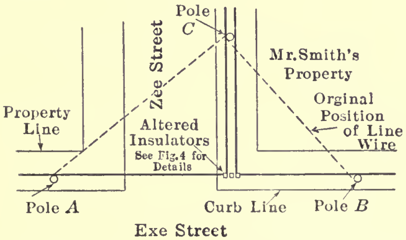


FIG. 6.—SOLUTION OF A RIGHT-OF-WAY DIFFICULTY.

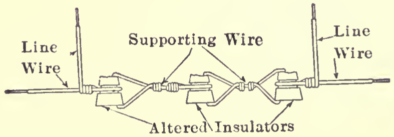


FIG. 7.—PLAN VIEW OF INSULATOR ARRANGEMENT.

building were taken had been pulled partially over through the breaking of a guy wire, that the service wires had been broken, and that the iron brackets and the wooden cleat which supported them had been pulled down. It was impossible to replace the cleat and bracket with the tools the man had and he could not pull the pole back into normal position, so he restored service temporarily by driving spikes at the corner of the

building and supporting the service wires on the spikes with altered insulators as shown in Fig. 4.

Altered insulators can be used for tree insulators as suggested in Fig. 5. Where a line wire is in contact with the limb or branch of a tree it is usually possible to eliminate the contact by placing the line wire in the groove of an altered insulator and pulling and tying it away from the offending member with a pull-over wire as may be seen in Fig. 5. The line wire is sometimes tied in the groove of the insulator, but, as a rule, this is not desirable because if the line wire is tied the swaying of the tree may break the conductor. Tree insulators specially formed from glass or porcelain are made and are preferable for permanent work to the altered type of Fig. 5.

A right-of-way difficulty was solved with altered insulators in the instance pictured in Fig. 6. Wires of a series circuit spanned, as shown by dotted lines, from poles *A* and *B* to pole *C* and one of them crossed property. To the presence of this wire the owner objected and insisted that it be removed. The heavy lines show how the wires were rearranged to meet the property owner's demands without setting a pole. Fig. 7 shows the arrangement used and the wiring of the altered insulators. The wiring was made up on the ground, after careful measurements had been taken, and was then raised to its aërial position before the original wires, shown by the dotted lines, were removed. The new work was then spliced to the portion of the old that was to remain and the useless part of the old installation was cut down.

Concrete Poles Integral with Building to Save Space.—At the No. 3 plant of the Aluminum Company of America at Niagara Falls, N. Y., the problem of conserving real estate has been solved in one instance by resorting to a novel type of overhead-line construction. The motor-service wires reach the mill over a pole line and from the corner of the low concrete building which adjoins the main factory are carried by concrete poles constructed integral with the building. As shown in the upper, Fig. 1, page 49, the reinforcing extends up the wall of the building and continues to a point near the top of the pole. Braces of reinforced concrete are set on three sides of the poles at an angle of about 45 deg. The poles extend about 10 ft. above the roof, giving ample clearance between the wires on the lower cross-arm and the roof. This arrangement has the further advantage of allowing the spur track which is shown beside the wall to be placed closer to the factory than would have been possible if wooden poles had been set in the earth near the building. Thus in loading and unloading cars the distance between the car door and the sill of the factory entrance is reduced to a few inches.

Temporary Cross-arm Braces to Aid Construction Crews.—Quantities of strong and vivid language are often wasted by the foremen of line

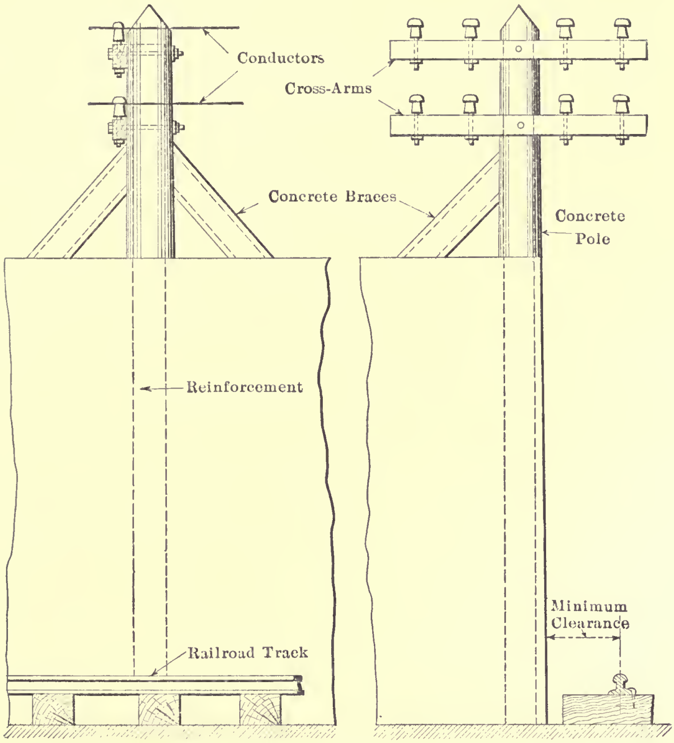


FIG. 1.—CONCRETE POLE INTEGRAL WITH BUILDING TO SAVE SPACE.

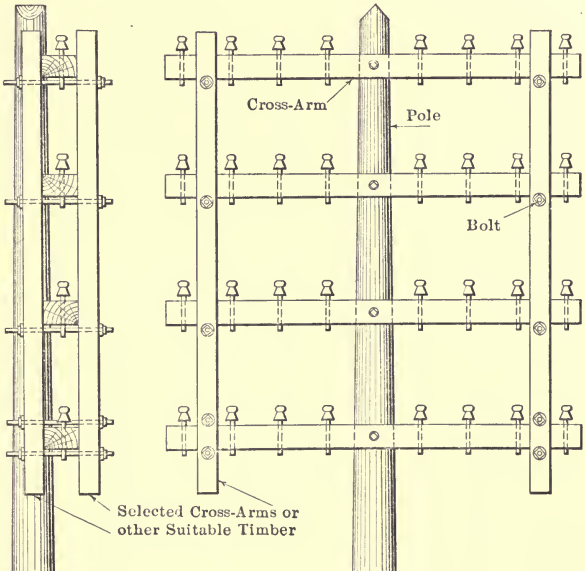


FIG. 1.—TEMPORARY CROSS-ARM BRACES TO AID CONSTRUCTION CREWS.

gangs when they find that the cross-arms on a pole which has been used by the men for a "resting place" while pulling wires, splicing and testing are out of line when the job is finished. An Ohio foreman is saving much of his formerly wasted energy by resorting to the expedient shown in the lower Fig. 1, page 49. A set of cross-arms of straight 2-in. by 4-in. pine timbers properly bored and fitted with bolts is carried as part of the construction equipment, and when it is necessary for several men to work on a pole for any considerable length of time the temporary braces are used to hold the arms in place. Ordinary 0.25-in. space bolts are found satisfactory for holding the braces to the arms. In work of reconstruction where the old cross-arms and poles are rotted at the gains this brace is also useful.

Operating Results with a 2300-volt Single-wire Ground-return Transmission Line.—In April, 1913, the Benton Harbor-St. Joseph

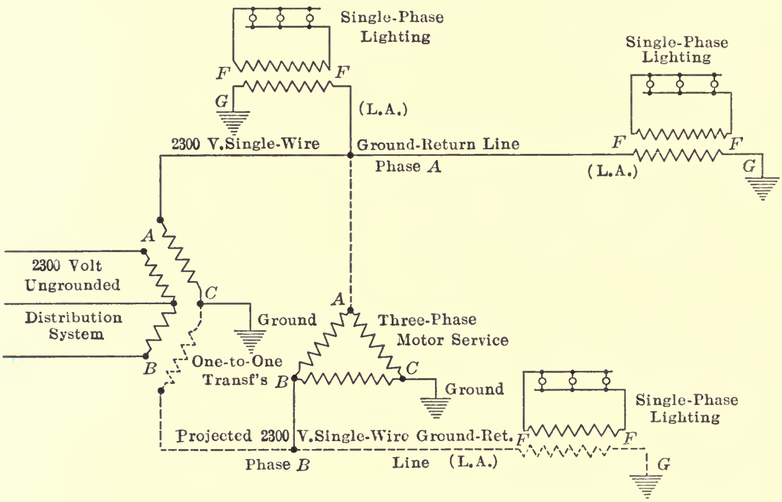


FIG. 1.—A 2300-VOLT SINGLE-WIRE GROUND RETURN TRANSMISSION LINE.

(Mich.) Railway & Light Company began the construction of a 2300-volt single-wire ground-return transmission line. Regular service began June 1. For the purpose of the severest possible test, this single-wire grounded line was built under the most adverse conditions that such a line could be expected to meet. A telephone company already had a line of poles along the route, carrying a rural-line circuit of two wires on brackets. Permission was obtained to reconstruct this line by placing a standard 5-ft. four-pin cross-arm in the top gain of these 25-ft. poles, transferring the telephone wires to two pins on one side of the arm and running the 2300-volt wire on the outer pin at the far side. The single-wire line thus built is approximately 2.5 miles long. Triple-braided

weatherproof wire was used throughout for both primaries and secondaries. Owing to delay in securing the one-to-one transformers desired for connecting the ground-return line with the company's ungrounded system, a pair of standard distribution transformers were utilized, their secondaries being connected together to take the place of the one-to-one units.

Customers' secondaries (see Fig. 1), are not grounded, and all possible effort is made to prevent such grounding. Lightning arresters are installed at every transformer. Transformers are fused between terminal and ground and between the primary wire and ground. Both secondary and transformer construction is of the company's standard type, the second or grounded wire of the primary being run to a No. 4 rubber-covered conductor, which is nailed to the pole and covered with special wood molding. This ground wire connects with both a 24-in. copper ground-cone buried in moist earth, with one sack of charcoal around the cone, and a 0.75-in. galvanized ground-pipe driven deep into the earth at the base of the pole. In some cases it was necessary to go back two or three poles to find lower ground which would retain moisture better.

Leaving the main transformers, at the end of the first five poles, it became necessary to cross a millpond with a 575-ft. span. This was done with a single messenger and two No. 8 triple-braided weather-proof wires carried on a specially insulated hanger so arranged that if necessary the entire span could be drawn in at either end and any necessary repairs made directly from the pole. Two wires were carried across this millpond in the expectation that a little later the second phase might be run out on another circuit, thus assisting in balancing the system.

When first starting a great deal of trouble was experienced with induction on the telephone lines. Finally the telephone wires were transposed every fifth pole, using standard Michigan Telephone Company transpositions. This helped the matter, but there was still considerable noise caused by grounds where the primary line ran through trees, some sections of the line traversing heavy maple, elm and willow shade trees. This trouble was only partly cleared up before the men were called away. After the line had gone through several severe electrical storms the men were again put on the line, thoroughly clearing it of all tree grounds, etc. While there is still a slight buzzing, caused by induction and noticeable when using the rural telephone, it cannot be detected at the other end of the line and the voice transmission is perfectly clear and normal. Not a single fuse on this line has been put out by lightning, either on the transformers or in residences. At the time of writing, there were no motors on the line.

The company is thoroughly satisfied that with a properly constructed

pole line on a private right-of-way, avoiding heavy trees such as shade many rural highways, single-wire lines can be built much more cheaply than the standard two-wire construction and with less danger from high winds, sleet and other line troubles. A line of this character using 25-ft. poles with 5-in. tops costs about $228.65 per mile as itemized in this table:

Thirty-five 25-ft. poles (5-in. tops), at $2.50	$87.50
Five 35-ft. poles, at $3.65	18.25
Thirty-five wood brackets, at 2 cents	0.70
Five four-pin cross-arms, at 40 cents	2.00
Twenty wood pins, at 2 cents	0.40
Forty glasses, at 2 cents	0.80
Bolts, lags, etc	1.00
400 lb. No. 8 triple-braided weatherproof wire, at 17 cents	68.00
Labor	50.00
Total	$228.65

A line of equivalent capacity constructed of the same material, but employing the usual two wires instead of one, would cost $380.30 per mile, a difference of $151.65 per mile. It will be noted in the above tabulation that no estimate has been made for the necessary amount of two-wire line where transformers were installed, nor for the grounding of transformers. The latter costs about $5 per transformer.

Changing 35,000-volt Insulators on Live Circuits.—To change insulators on a 35,000-volt transmission line while several large glass factories are taking energy from the line is rather an uncommon feat. Such work was, however, performed by a lineman of the Marion (Ind.) Light & Heating Company on one of its transmission lines not far from the city limits. A common hand-axe handle made into a wrench and insulated with four thicknesses of varnished cambric held in place with friction tape was used to free the line from the insulator. The handlines used in the operation were baked over night in an oven to drive out all moisture. In a very short time the broken insulator was removed and a new one put in its place. The fact that the wishbone cross-arms on the line were all grounded made the feat an exceptionally perilous one.

Concrete Resistors for Lightning Arresters.—Concrete resistors for lightning-arrester service which are in general use on the 11,000-volt and 22,000-volt systems of a Georgia central-station company are shown in Fig. 1, page 59. Into a solid concrete block measuring approximately 4 ft. long and 1 ft. on a side are cast two squares of bronze or copper mesh, one near each end. The block is then stood upright at the point of installation, being set a few inches into the earth to insure it against accidental overturning. To the upper-mesh electrode is connected the tap from the middle member of the double horn-gap, the circuit through to the transformer or other station apparatus being

completed by a piece of copper-wire fuse, as shown. The lower-mesh electrode imbedded in the block is similarly connected to a couple of 8-ft. ground pipes or ground rods driven deep into the soil. While the circuits are also adequately protected on the low-tension side, the fuse shown is especially provided for protection to the high-tension line. The copper-wire link used is designed to give four times the full-load carrying capacity and each lineman carries in his pocket notebook a table of sizes suitable for the various installation ratings at both 11,000 volts and 22,000 volts.

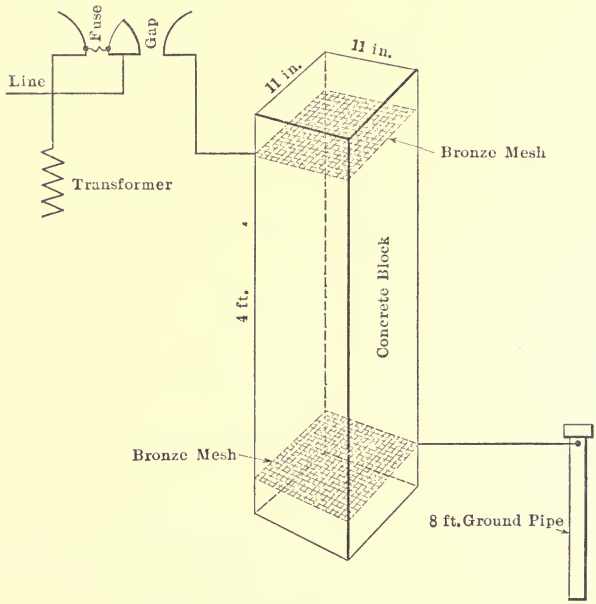


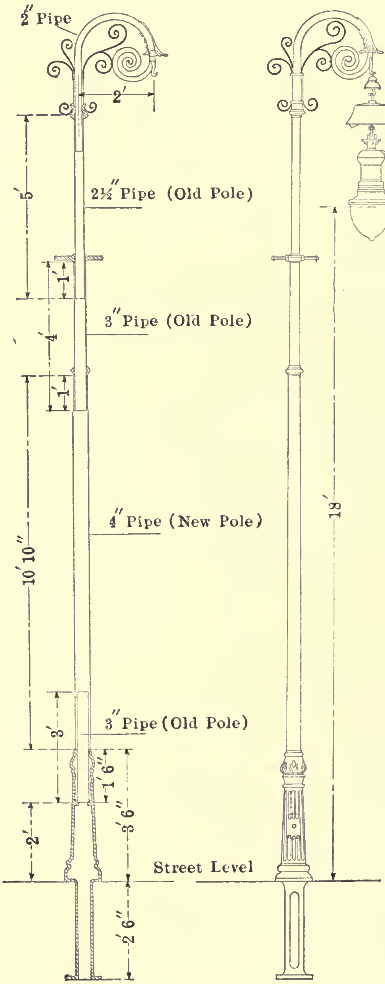
FIG. 1.—CONCRETE RESISTORS FOR LIGHTNING ARRESTERS.

Raising the Height of Old Inclosed-Arc Lamp-Posts at Cincinnati, Ohio.—The large number of inclosed-arc lamps which formerly lighted the streets of Cincinnati, Ohio, were replaced, late in 1913, with 6000 4-amp. magnetite units, but the new high-powered illuminants when hung from the posts which carried the older lamps were found to give trouble and even discomfort from glare in the eyes of passers-by. This difficulty had not been apparent with the former low-powered units, but became so critical with the initial trial installations of the magnetite lamps that it was found necessary to raise the posts by about 7 ft. 6 in. and so increase the visual angle.

The sketches herewith show how this change was accomplished by first sawing in two the old shanks and then socketing these stumps into pieces of 4-in. pipe, 10 ft. 10 in. in length. The original standards were of 3-in. pipe, which was found to fit snugly inside the 4-in. extension

piece. An ornamental cap was added at the top of the extension to make a neat-fitting joint. Above this point the old poles were tapered into 2.5-in. pipe, and again to 2-in. pipe to form the curved neck.

The reconstructed poles place the point of lamp suspension at a height of 21.6 ft. above the pavement level, bringing the arc itself at a height



FIGS. 1 AND 2.—RAISING THE HEIGHT OF OLD ENCLOSED ARC-LAMP POSTS AT CINCINNATI, OHIO.

of about 18 ft., well out of the way of direct vision. Figs. 1 and 2 show respectively the sectional construction of the rehabilitated posts and their appearance when the work of raising and reconstructing them had been completed.

Support of Long Transmission Span by Messenger Cable.—After the completion of the Eastern Michigan Edison Company's hydroelectric plant at Ann Arbor, Mich., an unexpected market for energy opened up in two towns, to the north and west respectively. To transmit energy to the latter place by the shortest practicable route, it was necessary to string the 23,000-volt conductors across the pond above the dam, requiring a span of about 1000 ft. Figured for tension, No. 0 hard-drawn copper wire was found to have just sufficient strength to be used safely on this span. However, while a jumper from the station high-tension bus was being soldered onto one of the span wires the heat of the solder annealed the hard-drawn copper, so far reducing its strength that the conductor broke under its own tension. To avoid using the larger wire needed to withstand the tension, the construction shown in Fig. 1 was

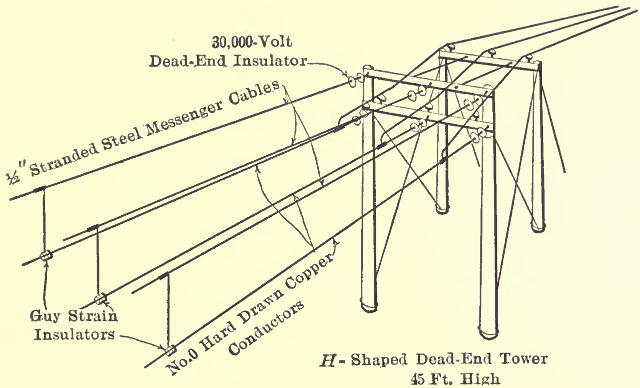


FIG. 1.—SUPPORT OF LONG TRANSMISSION SPAN BY MESSENGER CABLE.

then adopted. H-shaped wooden frames were built and erected on each side of the pond as dead-end towers. Back of each on its land side another H-shaped frame was erected to help withstand the horizontal pull of the long span.

The main dead-end towers are constructed of 45-ft. poles with 8-in. tops and are provided with two cross-arms. Attached to each arm are three 30,000-volt dead-end strain insulators, and crossing the pond between the insulators on the upper arms are strung three 1/2-in. stranded-steel messenger wires. Suspended from the messenger wires at points dividing the span into three parts are hangers which support ordinary guy strain insulators. Through these pass the main copper conductors, which are dead-ended on the lower set of insulators. This particular span was erected in July, 1913, and a 20-ft. sag was allowed.

III

METERS

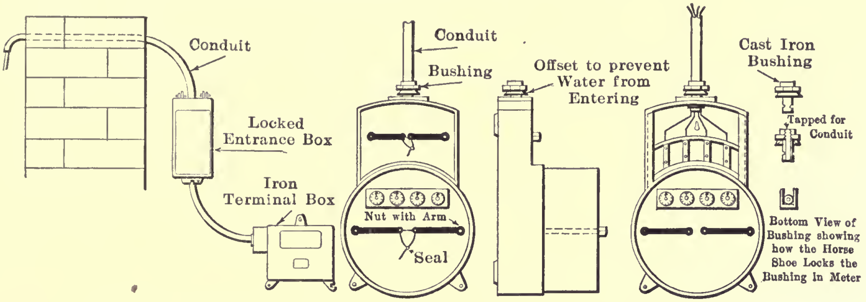
Handling, Identification, Protection, Rate Checking, Measurement and Testing

A Labor-saving Meter Truck.—A meter truck which is in service at the laboratory of the United Electric Light Company, of Springfield, Mass., offers a good home-made means for facilitating the handling of meters. The truck is 5 ft. 6 in. long by 2 ft. wide and is built with double shelves, its carrying capacity when loaded being forty-two meters. The frame is mounted on rubber-tired wheels and is equipped with substantial grab-handles bolted to the base of the truck with iron straps. The use of rubber-tired wheels enables the truck to be run about at reasonable speed without endangering the moving elements of the meters or their suspensions.

Tagging Meter Loops.—The meter department of a Western company which keeps ten or more wiremen busy wiring old and new houses, apartments, etc., employs one man whose sole duty is to check and tag meter loops after the wiring is in place. Aluminum name tags are used for this purpose, the company having purchased outright, for $35, a stamping machine similar to those familiar coin-operated devices installed about railway stations and other public places. The aluminum strip out of which the plates are punched costs about 75 cents per pound, making the tags inexpensive as well as durable. The tag inspector first visits the job while the wiring is being installed and traces out the various circuits, making notes of the labels needed. Returning to the office, he stamps out the names on the plates, and on the next day he affixes the tags.

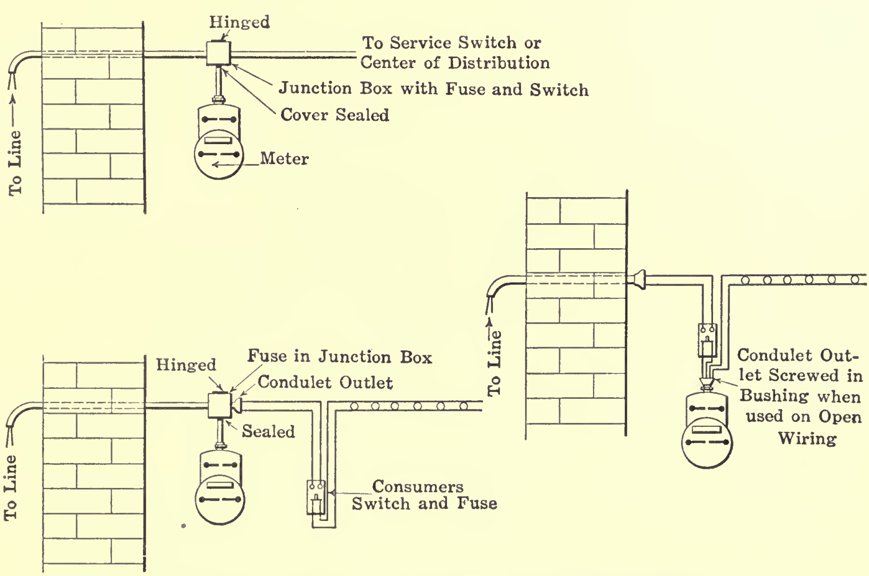
Protection of Electric Meters (By Robert Montgomery).—In Fort Worth, Tex., use is made of the arrangement shown in Fig. 1 to protect meters against tampering, while still permitting the customers to read them. A small iron terminal box is fastened to the meter in such a way that it cannot be removed without breaking the seals of the meter, and the entrance box containing the switch is also sealed. This method is very effective, and were it not for the cost and the difficulty of fastening the terminal box to the meter case it would be very practicable. The meter manufacturers can furnish a solution of this problem with very little expense by providing every meter with a device for fastening it to a conduit and sealing it. In 1911 many experiments were made at Fort

Worth along these lines. One plan is indicated in Figs. 2, 3 and 4. A meter with an outlet of this kind could be installed in houses already wired in conduit as is shown in Fig. 5. Where a residence or other building was wired with open wiring the meter could be arranged as shown in



FIGS. 1, 2, 3 AND 4.—DEVICES USED FOR PROTECTING METERS AT FORT WORTH, TEXAS.

Fig. 6. In places where it is not necessary to protect the meter it could be installed as shown in Fig. 7. Fig. 4 shows that the cast-iron bushing can first be screwed on the conduit and the meter slipped over the



FIGS. 5, 6 AND 7.—APPLICATION OF METER PROTECTORS TO VARIOUS CLASSES OF WIRING.

bushing. Then the horseshoe device is placed over the bottom of the bushing, thus locking the meter to the bushing in such a manner that it cannot be removed unless the seals of the meter are broken. Another

advantage is that the case of the meter would not be strained as it would be if the conduit is screwed directly to it.

Two-meter Off-peak Rate at Salt Lake City.—To any customer under its retail schedule who defrays the cost of a time switch and pays the minimum charge for a second meter (making a total minimum of $2 a month), the Utah Light & Railway Company, of Salt Lake City, offers off-peak energy at a reduction of practically one-half its full-rate charge. The peak hours during which the two-meter customer is charged the full rate are specified for each month in the year, and the time-switch settings are changed accordingly. During these hours the time-switch opens the shunt circuit of the low-rate meter and closes that of the high-rate meter, transferring the registration of the load from one instrument to the other.

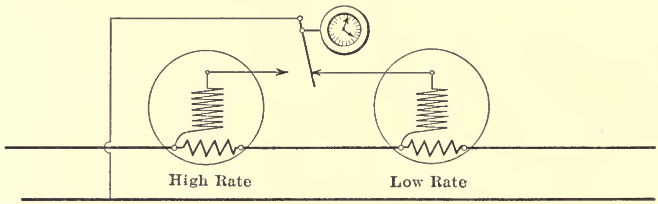


FIG. 1.—TWO-METER OFF-PEAK RATE CONNECTIONS, SALT LAKE CITY.

The scheme of connections is shown by the diagram, Fig. 1. The cost of the time switches alone on those installations thus far put in service has averaged $25 per switch, the best grade of Anderson and Campbell clock switches being used. The meter department of the Salt Lake Company is now experimenting with the construction of a less expensive switch which it is hoped can be marketed to the customer for $10 or less, bringing the off-peak schedule more within the grasp of the average user. An inspector mounted on a motor cycle makes weekly rounds of the two-meter installations, overlooking them and setting and winding the clocks. The customer, however, agrees, if requested, to keep his clock mechanism wound.

Use of Single-phase Wattmeter on Polyphase Circuit (By John Gilmartin).—In measuring the load on three-phase motors in industrial establishments it often happens that high accuracy is not necessary and a single-phase wattmeter can be used, the load being assumed to be balanced. The most usual method for this purpose is shown in Fig. 1, page 59, where the series coil of the single-phase wattmeter is inserted in one line and one end of the shunt coil is connected to the line having the series coil and the other end is joined successively to each of the other two lines. The algebraic sum of the two successive readings is the three-phase load. This is essentially a balanced load method, as it assumes that the voltages, currents and wattages in each phase are equal.

Fig. 2 shows the familiar star-box method of measuring balanced three-phase loads, in which the total power in the circuit equals the wattmeter reading multiplied by three. The two external resistances connected to the lines are exactly equal to each other and to the resistance of the shunt circuit of the meter. This method is as accurate in theory as that of Fig. 1, but in practice would usually give more accurate results, because there is no algebraic summation of readings to be made and no chance for

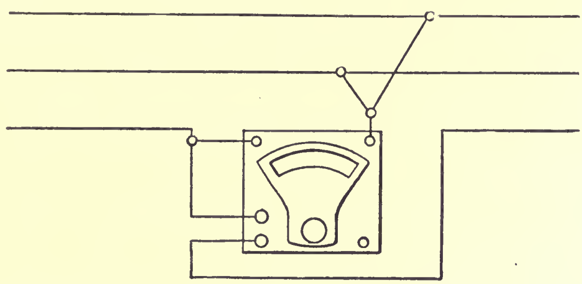


FIG. 1.—SINGLE-PHASE WATTMETER FOR MEASURING POLYPHASE LOAD.

error due to the load changing, as may happen with the arrangement of Fig. 1, when the meter is dead during the change of the wattmeter shunt-coil tap from one wire to the other.

The objection to the star-box method is that a single-phase indicating wattmeter is not provided with a star box, and therefore the method of Fig. 1 is the only one available if it is desired to measure three-phase power.

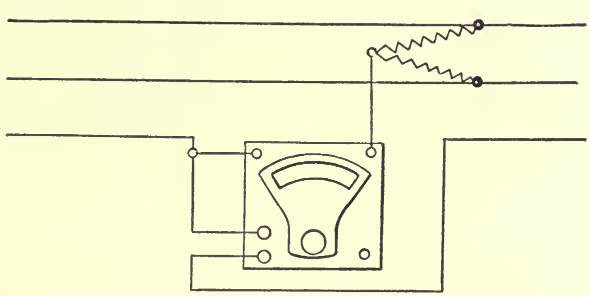


FIG. 2.—STAR-BOX METHOD OF MEASURING THREE-PHASE LOAD.

A certain company has adapted its single-phase indicating wattmeters for use in a star-box arrangement, as illustrated in Fig. 3. The wattmeters in question were self-contained but were provided with external multipliers for extending the voltage range from 150 volts to 300 and 600 volts. A tap was brought out midway between the 2 tap and the 4 tap on the multiplier, thus giving a multiplier of three and making the resistance between the taps equal to each other and to the resistance of the

shunt circuit in the meter. This arrangement provides the essentials for the star-box method, the multiplier being connected to the three-phase line, as shown in Fig. 3. No attention need be paid to the figures given on the multiplier to apply to the wattmeter readings, as this instrument now reads one-third of the power and therefore the multiplying factor to be used is three.

This discussion applies to the dynamometer-type wattmeter, and the tap on the multiplier can easily be located by simply measuring the resistances with a Wheatstone bridge.

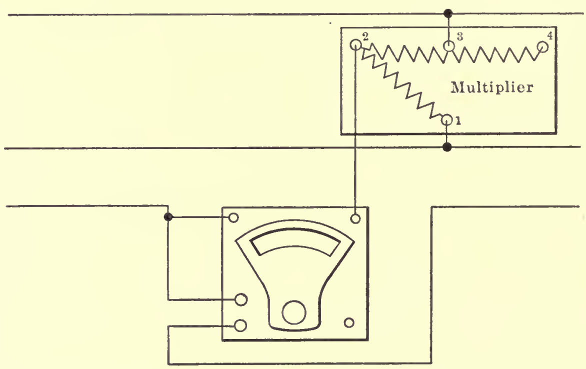


FIG. 3.—SINGLE-PHASE INDICATING WATTMETER USED FOR MEASURING THREE-PHASE LOAD.

Ohmic and Inductive Resistances of Meter-current Circuits (By H. S. Baker).—In measuring electrical energy by a watt-hour meter certain sources of error are commonly neglected, especially where the block of energy being measured is small. The errors referred to are those known as ratio errors and phase errors of series-instrument transformers and also of shunt-instrument transformers feeding the meter circuit in question. The ratio and phase errors of a series transformer are dependent upon the ohmic and the inductive resistances of the meter series circuit fed and upon the percentage of full-load current at which the series transformer is operating. Hence the accurate current ratio of a series transformer cannot be given except for given conditions. These errors frequently exceed 1 per cent. of the rated full-load amperage of the transformer, and where large blocks of energy are being measured the correction for these errors will soon more than pay for the trouble and expense of such determination and correction. An outline will be given below of a novel method of measuring the ohmic and inductive resistances of a given meter circuit (which is to be fed by the series transformer) in order that the operating conditions may be imposed upon the transformer while

under test. The following method of measuring the above circuit constants requires no source of direct current, but uses the polyphase e.m.f. supply which feeds the meter. Several amperes can be drawn from the secondary of a shunt-instrument transformer for a minute or so without running any risk of damaging the transformer. The method consists, in short, of measuring upon a wattmeter the reaction between a certain voltage drop *A–B*, Fig. 1, and a certain current fed from phases 2–3 through ohmic resistance, and again measuring the reaction between the same voltage drop and the current fed from phase 1–2. The case described is as supplied to an available three-phase e.m.f. supply 1–2–3, but the method is easily applicable to other polyphase circuits. In diagram Fig. 1 *P*, *Q*, *R* and *S* are nails driven in a board and connected as shown. The

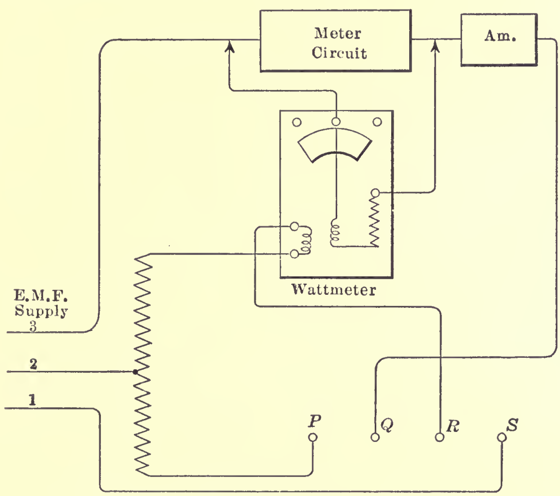


FIG. 1.—DIAGRAM OF CONNECTIONS.

rest of the apparatus shown is self-explanatory. When a jumper is placed from *Q* to *R* it will be seen that current is fed through the series coil of the wattmeter and through the meter circuit to be measured. Now the component of the voltage drop *A-B* which is in step with the current will cause the wattmeter to deflect. For example, if the reading is, say, 28 watts and if the amperage is, say, 6, then the ohmic component of the drop *A–B* is $28 \div 6 = 4.66$ volts and the ohmic resistance from *A* to *B* is $4.66 \div 6 = 0.78$ ohm. Now remove jumper *Q–R* and place jumpers on *P–Q* and on *R–S*, thus keeping the same current in meter circuit, but changing the phase of the current in the wattmeter series coil. The watt reading now is, say, 42. In diagram Fig. 2 the angle 3–2–1 is 60 deg., representing the two phases of the current against which the voltage drop *A–B* was caused to react in the wattmeter. The distance 2–*X* is

plotted to some scale to twenty-eight divisions, and the distance 2–y is plotted equal to forty-two divisions, as per above readings. Perpendiculars are erected as shown at X and y and their intersection at P is the end point of the vector 2–P, which represents the voltage drop A–B, and 2–X is the ohmic component and X–P is the inductive component. Scaling off X–P to the same scale it is found to be 32.3 divisions or "inductive watts." Then the inductive volts are $32.3 \div 6 = 5.38$ volts and the inductive resistance is $5.38 \div 6 = 0.9$ ohm. The apparatus required for the above measurements will be seen to be simple and the values of resistances obtained are reliable within a few per cent., which is sufficiently accurate for the purpose in hand, as the total effect of the resistance upon the ratio of the series-instrument transformer is in general under 2 per cent.

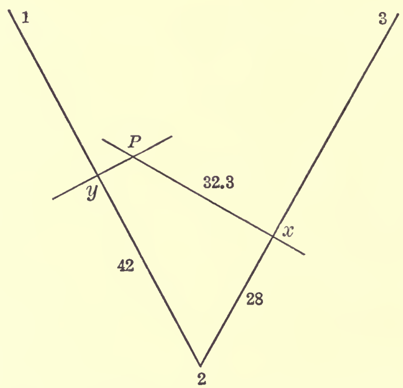


FIG. 2.—GRAPHIC SOLUTION OF PROBLEM.

Pendulum Counting Device for Testing Meters.—For testing rotating-standard meters C. B. Stelle of the Springfield (Ohio) Light, Heat & Power Company, makes use of an improved pendulum counting device. Its application depends upon the fact that if T be taken as thirty-six seconds, the familiar meter expression $\frac{3600 \times K \times R}{T}$ becomes merely the product of the constant times the revolutions multiplied by 100, a result easily computed. The device shown in Fig. 1 comprises a one-second pendulum and counter cam which automatically connects the meter in circuit for thirty-six-second test periods, thus fulfilling the above condition.

This apparatus avoids the use of a stop watch, and requires only one man to make the test. It also tests the rotating standard from start to stop each time, duplicating the conditions of the test meter's practical use. The Springfield company employs two rotating standards, one of which is calibrated every three days. No attempt is made to adjust the standard, but a calibration curve of its errors at varying loads is prepared.

The 39.5-in. pendulum shown consists of a wooden rod boiled in paraffine and carrying solder-filled bobs, the whole being hung from a four-jewel meter bearing. The slight impulse needed to keep the pendulum in continued motion is supplied by the solenoid winding at the left of the bob. A contact pin on the pendulum swings through a globule of mercury, actuating the counter solenoid. To avoid destructive sparking at the contacts, which was at first experienced, these contacts simply close secondary windings of potential transformers whose primaries are in series with the solenoids and resistor lamps. As long as the secondaries are open the current passing through the solenoid is small, but when short-circuited enough current flows to operate the mechanism.

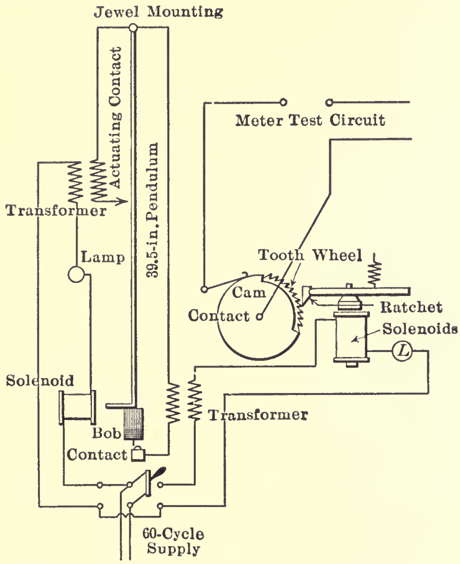


FIG. 1.—PENDULUM COUNTING DEVICE FOR TESTING METERS.

For the cam wheel a couple of meter disks were used, one having been filed with sixty teeth and the other having its periphery cut away for an arc equal to thirty-six of the teeth. The wheel is thus rotated through the intervals of one tooth every second, completing a full rotation in one minute. For thirty-six seconds of this period the contact brush bearing on the cam surface closes the meter circuit, breaking it again automatically at the end of that period. By means of the double-throw switch at the bottom the counting device may be disconnected while the pendulum continues in operation. This feature is useful while warming up a meter preparatory to making the test. In the right-hand position both pendulum and counter are actuated. The mechanism was built almost entirely of old meter and arc-lamp parts.

Testing Shunt-type Watt-hour Meters (By R. Toensfeldt).—The accuracy of certain meters came under suspicion when it was found that the sum of the panel meter readings did not check with the reading of the totalizing meter. In order to find which was inaccurate it was decided to calibrate and check each of them. The meters were of the shunt type operating on a three-wire system and having one coil in each leg of the 125/250-volt lighting circuit. After trying several methods and finding them very unsatisfactory, it was decided to supply the watt-hour meter directly from some large source of energy. Accordingly an old barrel was rigged up as a water rheostat and connected in series with a set of terminals directly across the 125-volt buses on the board as shown in the drawing, Fig. 1. The connecting terminals *cc* are two independent pieces of old bus-

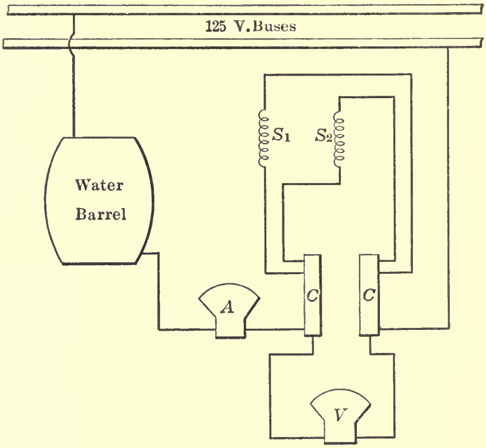


FIG. 1.—TESTING SHUNT-TYPE WATT-HOUR METERS.

bar, tapped and provided with cap screws, which were made merely as a convenience for connecting the meters into the circuit. The coils of the watt-hour meter s_1s_2 were connected to these buses, and a millivoltmeter v connected in multiple with them. An ammeter A was put in the circuit chiefly as a matter of check on the current taken by the watt-hour meter. By varying the resistance of the water barrel any desired drop across the terminals of the watt-hour meter was obtained. Therefore, considering 80 millivolts as full-load drop across the meter terminals, this figure being obtained from the manufacturers, it was possible, by proper manipulation of the rheostat, to apply any desired load to the watt-hour meter. The pressure leads of the meter were not disturbed.

The test was made in the usual manner, timing a certain number of revolutions of the spindle, calculating from this the number of kilowatt-hours recorded in one hour and comparing this with the load calculated from the millivolt drop.

In testing the meters for a perfectly balanced load, the testers simply multiplied the meter terminals on the connectors; that is to say, the positive terminal from the positive bus and the positive terminal from the negative bus on the same connector and the other two terminals on the other connector. In this way each coil received the same current, representing a perfectly balanced load. For unbalanced conditions one coil was left open and the other was tested at various loads, then the first tested the other in a similar manner at the same loads. This, of course, would represent extreme conditions, but it was believed that a meter which registers correctly under these severe conditions of unbalancing and also on condition of perfect balance will be reasonably sure of giving good results on intermediate conditions.

These tests proved remarkably convenient and efficient, fulfilling all expectations. They have the advantage of not in any way disturbing the load while the test is going on, only affecting the load records for the time consumed in testing and adjusting, which can easily be corrected from the previous records. No large currents are required for the test and it is not necessary to unbalance the generators more than 25 per cent. to obtain extremely unbalanced load conditions.

Ammeter Testing (By G. C. Cassard).—There are two generally recognized methods of calibrating direct-current switchboard ammeters under operating conditions. In the first, or "direct," method a standard ammeter (or shunt and millivoltmeter) is connected in series with the shunt of the meter to be tested, and the reading of the latter is compared directly with that of the standard. In the second, or "potentiometer," method the drop across the shunt is measured by using a potentiometer and the corresponding current is taken from a table previously compiled and compared with the reading of the switchboard meter.

The writer has no intention of comparing the merits of these two methods, but would point out that any method necessitating connections directly to live copper and depending for its load variation on manipulation of the outgoing current is objectionable and should not be tacitly accepted without an effort to substitute something more efficient.

If it were possible to measure the small shunted current in the instrument itself, for instance, and to know what scale deflection such current would produce, it would be quite practicable to substitute this current by using a small battery and rheostat, and thus to make the test in a position as remote from the switchboard as desired. The several resistance factors involved would have to be known, however, to accomplish this result, taking account, of course, of the actual temperature at which any test might be made.

As an imaginary case, suppose that, instead of using a shunt, the ammeter leads have been simply tapped to the outgoing copper at points

3 ft. or 4 ft. apart to provide the necessary drop. This introduces a temperature coefficient in this part of the circuit and is assumed simply to present a case involving this factor. To measure the resistance of this copper section it will be necessary to disconnect the ammeter leads and measure the drop between these points with a potentiometer. At the same time the current is measured by means of a portable ammeter connected in series. Thus, from Ohm's law, the resistance of this copper or "shunt" at the observed temperature of the test is obtained. Now by applying a temperature constant, as given in standard tables, this resistance may be immediately reduced to its value at a standard temperature of 75 deg. Fahr. Thus, calling the latter resistance R and X the resistance at an observed temperature of, say, 66 deg., $R = 1.02\ X$, since 1.02 is the constant indicated at this temperature. This value R is then stamped on the shunt, and, since it is unchangeable, it constitutes a permanent record.

To measure the resistance of the ammeter leads it is only necessary to attach a bridge to their lower ends and to remove the upper ends from the meter and bolt them together. This observed resistance is then reduced to its standard resistance at 75 deg. just as was done with the shunt, and this standard, r, is then noted on a tag and tied to the leads.

It will be understood that the above work is preliminary and need be performed only once, so long as absolutely reliable results are secured. The values obtained are obviously unchangeable and may be used in testing for an unlimited period. There remains then only one resistance to be measured—that of the ammeter itself—and this measurement must necessarily be made every time the meter is checked; indeed, every time the tester changes the internal calibrating coil, which is usually of a metal having a zero temperature coefficient and is included in the circuit of the copper coils of the instrument. This fact has no bearing on the results, however, since the total resistance in series is used at the observed temperature of the test, and is, therefore, not to be affected by a constant. R and r, on the other hand, must be reduced to the room temperature before being used, and since they were multiplied by a factor before to bring them to a resistance at 75 deg. it will be necessary to divide them by a factor.

By reason of the constant relation that the shunt and meter bear to each other at all loads, and by the simple law of two multiple circuits, $\frac{R}{K} : \left(\frac{r}{K} + r_1\right) = i : I$, in which R is the shunt resistance at 75 deg. Fahr.; r is the resistance of the ammeter leads at 75 deg. Fahr.; r_1 is the observed resistance of the ammeter; K is the temperature factor at observed temperature; i is the current in the meter circuit, and I is the current in the shunt.

From the above proportion $I=\frac{i(r+r_1K)}{R}$ is obtained as the value of the current in the shunt, but, as the current through the meter is too small to be read on its own scale, this value may be taken for the total current external to the shunt. The tester may, therefore, take the meter from the board and after connecting up to a suitable bridge and milliammeter, and measuring the resistance and current, the meter may be calibrated by above formula.

In applying a system of testing such as this it is evident that recourse must be had to an instrument of special design, which, while possessing

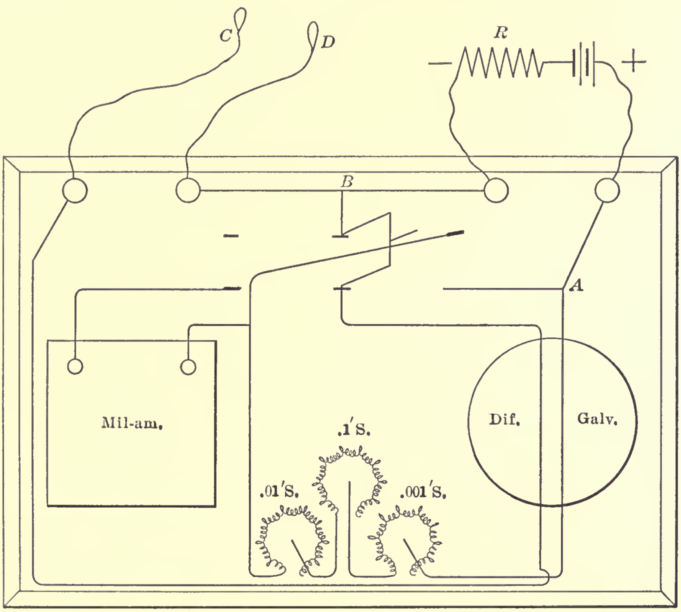


FIG. 1.—AMMETER TESTING SET.

a reasonable degree of simplicity, will lend itself readily to the measurement of both the resistance and the small meter current, and this without undue manipulation. These considerations were applied in designing the testing set described herewith, which may be made up in a form compact enough to fit into a small suitcase. (See Fig. 1.)

The double-throw switch provides for the uses mentioned by changing the arrangements of the circuits. The measurement of resistance is made with the switch thrown to the right. In this position there are two subcircuits. Starting from the positive side of the battery one of these circuits passes through the right side of the differential galvanometer, the resistance dials, the upper blade of the switch and returns to the battery. The other circuit, starting from the positive side, passes through the lower

blade of the switch, the left side of the galvanometer, the terminals CD (supposing the terminals to be bolted together) and back to the battery. The two circuits from the junction A to the junction B are of equal resistance when the three resistance dials are set at zero; therefore, any outside resistance connected between C and D may be accurately measured to thousandths of an ohm by balancing the galvanometer by the dials. By attaching these terminals to the binding posts of the meter its internal resistance is first measured. Since this same connection is used for the current measurement the tester may proceed by simply throwing the switch to the left. Now there is only one circuit, starting at positive, right side of galvanometer, resistance dials, milliammeter, lower blade of switch, left side of galvanometer, ammeter on test and back to the battery. In this position the galvanometer is not in use, but the milliammeter is, and it is found desirable to pass the current through the galvanometer twice for three reasons: First, since the current is the same in the two coils it will not deflect the needle; second, the increased resistance of the series connection added to that of the milliammeter which has just been switched in reduces the current flow when calibrating, so that greater battery strength may be used to give the galvanometer greater sensitiveness when balancing, and, third, with the series connection the galvanometer itself may be checked as to whether or not it is perfectly differential.

In the calibrating position of the switch it makes no difference in the accuracy of the ammeter how much resistance is in circuit, provided the resistance of the calibrating coil inside the ammeter is not changed. This seems inconsistent until it is remembered that a change in the calibrating coil means a change in the ratio of the meter to its shunt—that is, a change in the value of one factor (r_1) of the formula, which change should only be made in changing the calibration. So for varying the load the dial resistances are varied, but not read, the actual checking being made by the reading of the milliammeter as compared with the ammeter.

Testing Large Watt-hour Meters on Fluctuating Loads (By F. A. Laws and C. H. Ingalls).—All persons responsible for the upkeep of large direct-current wattmeters which are used on a rapidly fluctuating load, have experienced difficulties in the testing and adjustment of such meters. Owing to the large number of readings of the current which it is necessary to take in order to obtain a good average the ordinary method of using a stop-watch and of measuring the line voltage and current is a time-consuming operation, and in some cases the fluctuations are so rapid that the use of the ammeter is quite out of the question. An alternative procedure is to take the meter out of service and to send through its coils the current from a storage battery. This current may be controlled by resistors, so that tests at light load and up to 400 amp. may be made without the apparatus being too unwieldy to be managed by two persons. For

the purpose a couple of Edison cells are convenient, being readily portable. It is, however, desirable to avoid taking the meter out of service, and to make the test with the customer's regular load. These considerations have led us to devise other methods of attacking the problem.

The very convenient forms of test meters developed for alternating-current work naturally suggested similar devices for use on direct-current circuits. Such test meters are made up to a capacity of 150 amp. But for our purposes we desire meters which will take currents from 500 amp. up to the largest magnitudes met with in practice. The direct application of shunts to a test meter of the ordinary commutator form is not admissible. Since we desired to retain this type of meter, the following methods of

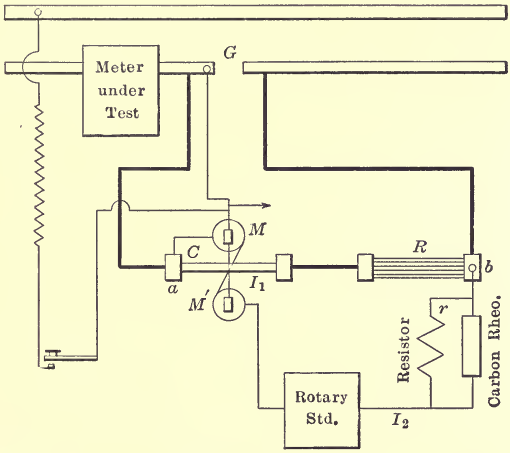


FIG. 1.—DIFFERENTIAL MULTIPLIER ARRANGEMENT.

dealing with the problem were devised; they may be regarded as arrangements by which shunts may be so applied to the test meter that errors due to contact resistances and heating are obviated.

The first method is shown in Fig. 1, where for the sake of simplicity the potential connections to the meters are omitted. The arrangement may be called a differential multiplier, for by it the range of the test meter is extended, in this case approximately thirty-fold.

The station busbar is arranged so that it has a narrow gap at *G*. This gap is ordinarily closed by plates firmly bolted in position. The gap should be narrow and the leads so arranged that the field at the meter is not disarranged when the gap is opened. The entire current flows to *a*, where it divides, a comparatively small portion flowing through the fine wire coils of the multiplier *MM′*, the test meter and the adjustable resistor *r* to *b*. The main portion flows through the "coarse coil" *C* of the multiplier, which is in this case a straight bar, then through the resistor *R*,

which is of such a magnitude as to give the voltage drop required in the test-meter circuit. The fields due to the currents in MM' and C are opposed, and in them is placed an astatic movable coil system which is provided with pivots and a damping device. The movable member, in series with a suitable resistor, is placed across the line and serves to show when the fields due to C and MM' are balanced. In the present instrument 30.7 amp. in C is required to balance 1 amp. in MM'. The multiplier is brought to a balance by varying r. When this has been done the corrected watt-hours by the test meter are obtained by multiplying its indications by 31.7.

The test meter is of course set up where it will be as free from stray field effects as possible. The leads to it are flexible and readings are taken with the meter in four different azimuths 90 deg. apart. For our work this has sufficed; but conditions may be easily imagined where, owing to the change in the distribution of current between feeders which

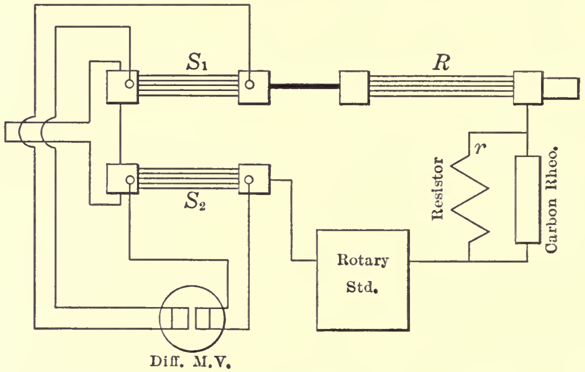


FIG. 2.—ARRANGEMENT ACCORDING TO TWO-RESISTOR METHOD.

are at different distances from the test meter, this procedure would not give the desired result. In such cases a shielded instrument would be desirable. The multiplier being astatic, with the centers of the upper and lower coils 2 1/2 in. apart, it is not affected by uniform stray fields. Anything that produces a non-uniform stray field—for instance a busbar close to the instrument—might, however, lead to a misjudgment of the balance. So the apparatus should be set up at a fair distance from the switchboard.

Appreciation of this possible difficulty led to the second method, which employs two appropriate resistors, one in the circuit of the test meter and the other in the parallel circuit, the potential drops in the two being made equal by the adjustable resistor r and this equality indicated by a differential millivoltmeter of the D'Arsonval pattern. This arrangement is indicated in Fig. 2. Any shunts which are suited to the purpose

may be temporarily bolted together and used for S_1 and S_2. They should, of course, be free from thermal e.m.f. errors. We have found this matter troublesome in some cases.

This arrangement may be simplified and the differential millivoltmeter replaced by a pivoted D'Arsonval galvanometer if a special shunt

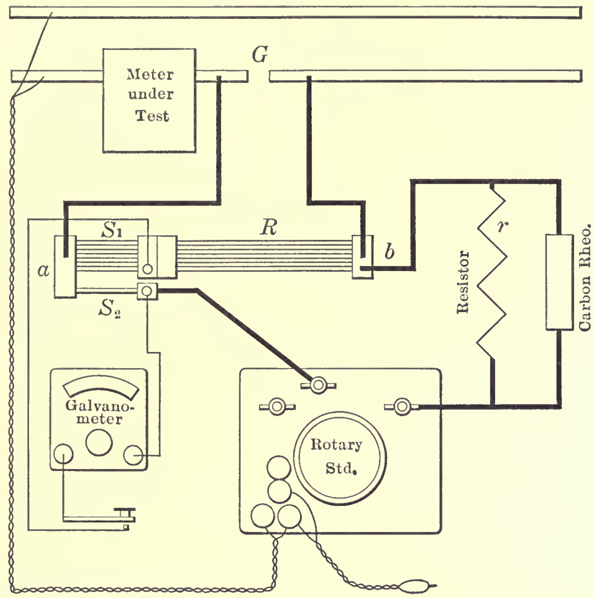


FIG. 3.—SIMPLIFIED TWO-RESISTOR METHOD.

be constructed for the purpose. The last plan is indicated in Fig. 3. The sections of the shunt (see Fig. 4) S_1 and S_2 have a common terminal at a. If the galvanometer stands at zero then $\frac{I_1}{I_2}=\frac{S_2}{S_1}$ and the corrected

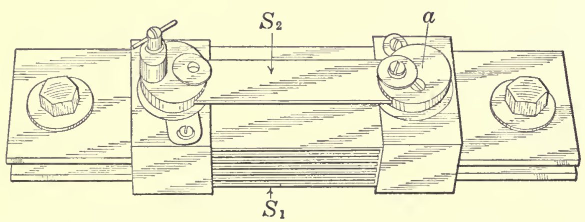


FIG. 4.—SHUNTS USED IN SIMPLIFIED METHOD.

reading of the test meter is its indication multiplied by $\frac{I_1+I_2}{I_2}$. By the use of two potentiometers to measure I_1 and I_2 when the galvanometer is balanced this factor can be very accurately determined once for all.

This is the final form of the apparatus and one which has been used very successfully for over a year.

The capacity of the test meter is 40 amp. Two sets of shunts and auxiliary resistances R are mounted on the same base; the ratings are 1000 amp. and 2000 amp. The voltage drop in the shunts at full load is 100 millivolts and in the resistor R it is 400 millivolts. The adjustable resistor r is a strip of Baker metal, the effective length of which can be altered by the use of screw clamps. Placed in parallel with the strip is a carbon compression rheostat by which the fine adjustment is affected.

The entire apparatus, including the necessary cables but not the test meter, may be stowed away in a chest 31 1/2 in. by 19 in. by 14 in. which can be conveniently shipped from station to station.

A Portable Stand for Graphic Instruments (By H. H. Kenney).—Graphic, or curve-drawing, electrical meters are very useful to concerns that employ many motors because with a graphic instrument a permanent accurate record of motor performance can be obtained. The curve, usually reading in either amperes or watts, indicates clearly what the average, maximum and minimum inputs to the motor are and it shows the time relations between them. It is impracticable to obtain significant records of these characteristics through the use of indicating instruments. In a reasonably large concern a graphic instrument will usually pay for itself the first year it is used by enabling its purchaser to select motors of the smallest capacity that will do the work.

When a motor drive for a new machine or application having unknown input characteristics is being arranged a spare motor should be geared to it temporarily. The input to the motor should be measured and recorded with a graphic instrument. From the curve thus obtained it will be possible to determine to a certainty the size of motor that should be purchased. No margin need be allowed so that the motor may be quite big enough. If necessary a curve-drawing instrument can be inserted in the motor circuit and be left there for a day or a week or a month, and it will, with little attention, accurately record what the input requirements to the motor have been for each interval of the time during the period.

Obviously, for such functions a graphic meter must be portable. It must be so arranged that it can be easily transported to and set up at any point in the plant. The better types of curve-drawing instruments have been designed for switchboard mounting, so that if they are to be made portable a special stand must be arranged for them. Fig. 1 shows a type of stand that is easy to make and cheap, and which will give good service.

Referring to Fig. 1: The stand is composed of three pieces of board about 1 1/2 in. thick. The actual thickness of the back board is determined by the thickness of the switchboard panel for which the studs and supporting bolts on the instrument are designed. Thoroughly dried

wood should be chosen for the support and a wood that will not warp readily is much to be preferred. The component pieces are held together with screws and they can be mortised one into the other if desired. After assembling, the whole should be well varnished to prevent any possibility of warping. The sizes of the component pieces of board and the locations

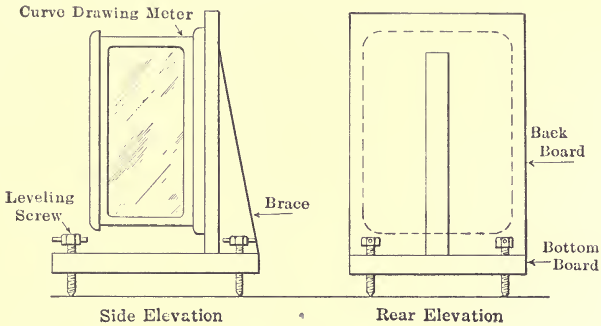


FIG. 1.—STAND FOR GRAPHIC METER.

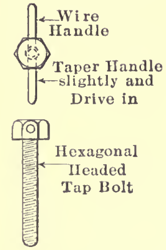


FIG. 2.—DETAIL OF LEVELING SCREW.

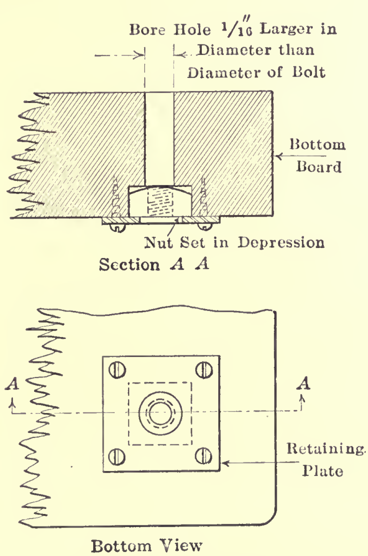


FIG. 3.—ARRANGEMENT FOR LEVELING SCREW NUT.

of the stud and bolt holes depend on the make of meter that is to be mounted. The manufacturer of the instrument will furnish a drilling templet and an outline drawing of it, but it is probably better to take dimensions from the instrument after it has been received.

Four leveling screws, one in each corner, are arranged in the bottom board. A meter of this type must be quite accurately leveled if a true

record is expected. The leveling screws are constructed as delineated in Figs. 2 and 3. The screw itself, Fig. 2, is made by inserting a slightly tapered pin through a hole drilled through the head of a hexagonal head tap-bolt of about 3/8-in. diameter. The pin, which serves as a handle, is formed from a drill or brass rod. It is driven snugly into the hole and because of its taper, will stay there. The nuts through which the leveling screws turn are arranged as detailed in Fig. 3. A square iron nut is tightly fitted into a depression cut in the bottom of the bottom board and a metal plate, fastened over it with wood screws, retains it. The round hole through the board for the leveling screw should be bored somewhat larger than the diameter of the screw so that there will be ample clearance.

Directions for the arrangement of electrical connections cannot be given because they are different for each make of instrument. For direct-current installations, where the voltage regulation is reasonably good, a graphic ammeter will draw curves which, by taking into account the voltage (which is assumed to be constant) can be calibrated in watts or horse-power. An ammeter is simpler than a wattmeter, is more easily connected and is, on the whole, preferable for direct-current work. But in alternating-current work, where low power factors are encountered and where the current taken by a motor may not be at all proportional to the actual power consumed, a wattmeter must be used.

One graphic instrument can be made to record the inputs to motors of small, large or intermediate capacities and of different voltages by providing suitable shunts and multipliers for direct-current instruments and series and shunt transformers for alternating-current instruments. The electrical manufacturers do not regularly list these "wide range" outfits, but on application will furnish data concerning them.

Watt-hour Meter Testing for Central Stations (By C. W. Ward and H. N. Stroh).—The writers have designed and put in use for the Duquesne Light Company, Pittsburgh, a test board or rack in which two or more portable service types of rotating standard watt-hour meters may be checked at the same time against a carefully calibrated laboratory rotating standard. The device reduces to a minimum the labor expense involved in the weekly checking of a number of portable standards, yet enables the inspector to maintain a very high degree of accuracy.

Primarily the rack is a large container built to accommodate the number of rotating standards desired. Westinghouse standards of the 5-amp. to 40-amp., 100–200-volt type are employed by the Duquesne Light Company, and the rack in use is built for twenty standards. The rack can, of course, be built to accommodate any type of standard.

From the accompanying Figs. 1 and 2 one can see at a glance the adaptability of the rack and realize what a time saver it is.

The meter movements as a whole are removed from their wood-carrying cases and their drums and contact fingers are carefully inspected, after which dust and foreign particles are blown out with heated compressed air. The complete movements are then inserted in the various compartments as shown. These compartments are so designed that the element has as exact a fit as when in its carrying case, being level, sealed from

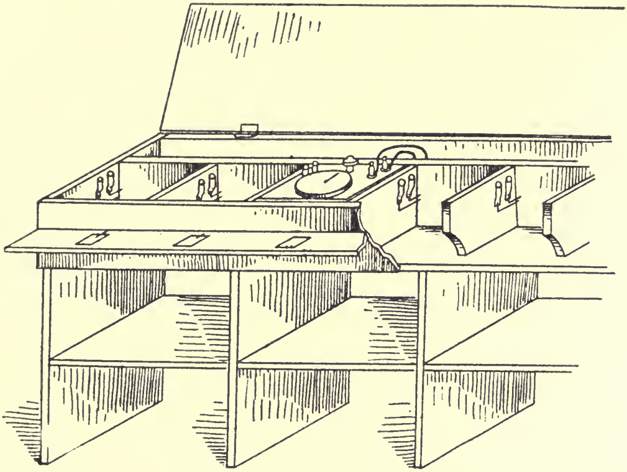


FIG. 1.—FRONT VIEW OF RACK.

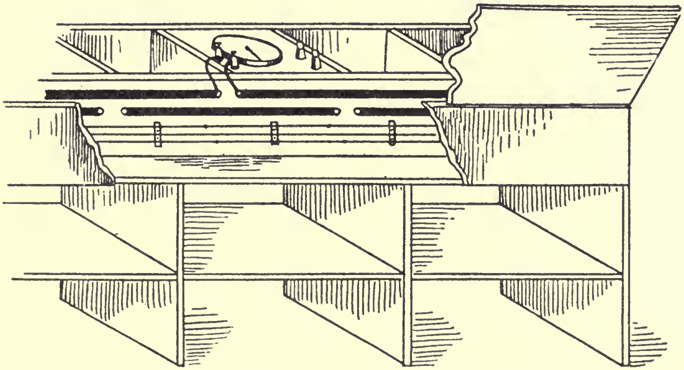


FIG. 2.—REAR VIEW OF RACK, SHOWING CURRENT BASES AND POTENTIAL CIRCUITS.

air currents, and with the shunt (potential) coils automatically cut into the circuit on the under side of the potential binding posts through the medium of the two springs shown on the left side of each compartment. These springs make a most positive connection and cannot get out of order.

The potential-coil connections are wired up in a special way to compensate for the drop in voltage when a large number of the standards are being checked at one time.

The series (current) connections to the standards are made by short, flexible leads coming up from the rear of the rack, along which run two flat copper buses, each capable of carrying 100 amp. From the sketch showing the rear of the rack it will be seen that these strips are split alternately at each meter and that no two adjacent meters are cut in on the same strip or bus. Such an arrangement neutralizes the effects of any stray fields set up by these buses.. The master meter employed as standard is of the regular Westinghouse rotating type with a few special modifications insuring greater accuracy and facility of handling.

Testing includes a check upon each series and shunt instrument winding and the error taken as final in each test is the average of three checks under each condition.

The usual method of returning to zero the pointer of each meter being checked is to employ a switch in the potential circuit of each. This method is slow and unsatisfactory. On this rack the front is hinged so that it drops down with counter-weights, thus exposing the moving element of each standard. The disk is then turned by a light pressure of the finger and the pointer brought exactly to zero at once. The calibration card foı each meter is always exposed for entries, being held by a spring clip on a small shelf directly in front of its respective meter. This shelf also prevents the warping of the hinged door, which effectively seals each compartment against the influence of air currents. A latch similar to that employed on refrigerators is used to hold this swinging front tightly in place when closed. Shelves are made underneath each compartment for the storing of the empty meter cases while the elements are under test. A hinged cover fits over the entire top of the rack, which is closed when not in use.

Each series winding is tested at full, half, tenth and twentieth load current and at both voltages, a total of ninety-six tests for each meter. These tests are made on Sunday, all standards being brought in Saturday by the testers. Thus on Monday morning a carefully calibrated standard is ready for each tester for his week's work.

IV

OPERATION OF, AND CHANGES IN CIRCUITS

Operation of Various Kinds of Circuits, Reducing Voltage Fluctuations by Different Means and Checking of Voltage Variations

Operation of a Two-phase Distribution System (By Alden W. Welch).—Where energy is transmitted over a three-phase, 25-cycle, 6600-volt circuit two-phase current is usually obtained by use of a frequency changer consisting of a three-phase, 25-cycle, 6600-volt motor, direct-connected to a two-phase, 60-cycle, 2700-volt generator. The two windings of the generator sometimes have a common connection, but more often the two phases are entirely independent of each other. At one time it was the practice to connect the two phases in series and run a common wire from their intersection, since by this method three wires were sufficient, while four were required for the operation of the two phases independently. The great disadvantage of this scheme is that if trouble occurs on one phase it will affect the operation of the other. A ground on one of the outside legs will produce a strain between the other outside leg and the ground equal to 1.41 times the volts per phase. The practice now is to transmit with four wires from independent phases and distribute with three wires from either one single-phase transformer having a split winding, if single phase is desired, or from two single-phase transformers having their windings connected for two-phase service.

When a number of customers in the same vicinity using both lamps and motors are to be served with energy, it is customary to make use of a four-wire, two-phase secondary. In this case the secondary of the transformer on one phase is connected to a three-wire, 120-volt service which feeds the lamp circuits, while for the motor circuits a second transformer, connected for two-wire, 240 volts is used. One secondary terminal of this transformer is connected to one outside secondary terminal of the lighting transformer and the other terminal forms the fourth wire of the secondary circuit. The wire running from the junction of the two transformers forms the common wire for the two-phase motors, the first and fourth wire being connected to the phase terminals of the motors. Reference to the diagram, Fig. 1, will make clear this method of operation. This method should not be used where the motor and lighting loads are simultaneous. The usual condition met with is that the motors are operated

during the day, while the lamps burn only at night. This maintains a balanced condition on the secondary.

The voltage is controlled by either a hand-operated or an automatic regulator. The latter method has been tried with great success, and following is a brief description of such a regulator. The control part of this apparatus is a contact-making voltmeter which consists of a solenoid having a shunt winding and a series winding acting in opposition. Mounted on a support is a lever, on one end of which are two contact points and on the other end is a core which is free to move within the solenoid. The contact points on the movable lever control the energy used in the relay switch, which in turn controls the circuit for operating the motor of the regulator.

In series with the shunt winding is a non-inductive resistance having taps for various voltages. The resistance is of such value that a current of

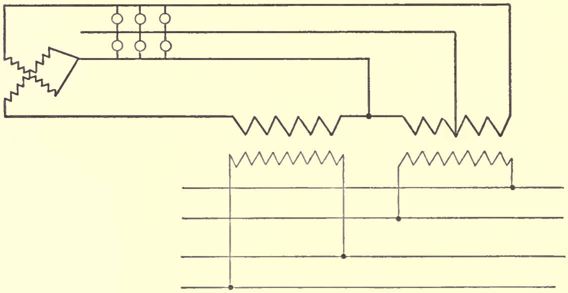


FIG. 1.—OPERATION OF A TWO-PHASE DISTRIBUTION SYSTEM.

about 0.8 amp. is carried in the shunt winding. The potential tap used for two-phase feeders is usually 120 volts. The series windings are divided into seven fine and two coarse adjustment windings, each of the coarse windings having about seven times the effect of a fine one.

In calibrating the contact-making voltmeter a spring on the lever is adjusted until the lever balances between the contacts with 120 volts on the shunt winding and no current in the series coils. In order that the contact-making voltmeter may compensate for the *IR* drop on the feeder at all loads, the number of series turns is adjusted to maintain normal voltage at a time when the feeder is carrying a heavy load at a power-factor of 90 per cent. until the effect of the ampere-turns due to the current is equal and opposite to that produced by the shunt coils, the lever balancing between the relay contacts.

Any increase in load on the feeder naturally increases the ampere-turns in the series coil and causes it to draw the core downward, the lever making contact on the upper stud. This operates the relay switch, causing the motor to operate the regulator in a direction to increase the

voltage until the pull exerted by the shunt coil balances that in the series coil. As the load decreases on the feeders the pull in the series coil decreases and the core is drawn upward, causing contact to be made on the lower stud. This energizes the relay in the lowering position and the regulator continues to lower the voltage until a balance is again restored to the solenoid windings.

For regulating the voltage of highly inductive circuits use is made of a compensating voltmeter. This instrument compensates for the inductance and *IR* drop, and is used for maintaining a predetermined voltage at the point of distribution irrespective of load or power-factor. The regulator should be connected between the feeder switch and the series transformer so that the ammeter will indicate the exact load carried by the feeder and not include that taken by the regulator. This is essential to good voltage regulation.

The following is the method for determining at what pressure a two-phase feeder should be operated when hand-operated or motor-operated regulators are used. The feeder is covered by testers. One is usually sufficient, but for feeders extending over a large area two or more testers are necessary in order to obtain satisfactory results. Pressure readings are taken by means of an alternating-current voltmeter at the cut-outs of certain customers, the aim being to obtain a general idea of the pressure conditions in all parts of the feeder. If the voltage is found to be nearly normal over the whole feeder, especially in the districts of heaviest load, a certain customer is selected on each phase, usually in the section of the heaviest load. These two locations are termed the balancing points and it is assumed that, conditions remaining the same, when the pressure is normal at these points the entire feeder is operating at satisfactory pressure.

At the balancing points, the station from which the feeder is being operated is called up by telephone and readings are obtained of the feeder load and feeder pressure as indicated by the station instruments. From the data obtained a curve is plotted, having feeder loads in amperes as abscissas and feeder pressures as ordinates. If 120 volts is considered normal pressure at the balancing points, and when that voltage is read the feeder is carrying 50 amp. high tension, at 130 volts feeder pressure at the station, read through shunt transformers, the curve would start at 0 amp. and 120 volts and pass through the point on the sheet representing 50 amp. at 130 volts. Two similar curves, one for each phase, are drawn on the same sheet.

If the loads on the two phases are nearly equal and correspondingly distributed, the two points representing the respective loads on the two phases should be plotted and a curve drawn bisecting the space between these points. The curve so determined should be used for operating

both phases. If the loads on the two phases are not evenly distributed, curves of both phases should be plotted on the same sheet. Under these conditions the two phases of the feeder would be regulated by different curves.

Curve *A*, Fig. 2, represents the previously noted condition when the conditions affecting the operation of the two phases are equal. Operating curves *B* and *C* do not coincide with each other, but the difference between them is so slight that curve *D* may be drawn bisecting the space between them. *D* now becomes the operating curve for the feeder, *B* and *C* being

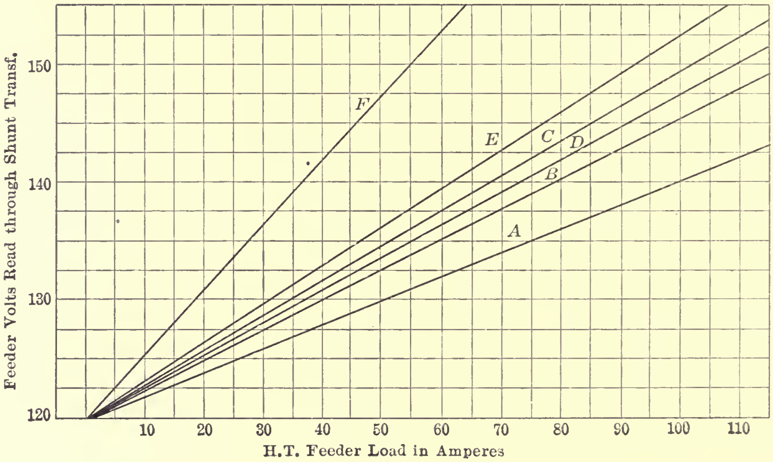


FIG. 2.—OPERATION OF A TWO-PHASE DISTRIBUTION SYSTEM.

erased. With conditions on the feeder such that the phase curves assume the positions *E* and *F* it would be necessary to retain both curves and operate each phase by the curve corresponding to it. All the curves start at 120 volts, which represents normal pressure at the customer's cut-outs.

With a hand-regulated feeder the operator reads the load on each phase and by consulting the curves finds at what pressure the feeder should be operated. When the load changes he raises or lowers the pressure to correspond. When automatic regulators are installed the curve is used for setting the contact-making voltmeter to operate at normal voltage at the balancing points. A general test should be made over the feeder about once a month.

It has been suggested that small shunt transformers be installed at selected points on the feeder and pressure readings taken at the secondaries of these transformers instead of at the customer's cut-outs. By this method the actual pressure of the feeder at a given point would be obtained. With the present method the feeder pressure often appears to vary on the same phase within a few hundred feet. This is due to the

load conditions on the various transformers. The writer recalls one case in which there were three customers on the three corners of a certain street fed by three individual transformers connected to the same phase. Two installations were being supplied with current at 120 volts, while the pressure at the third was 110 volts. An investigation showed that the low pressure was caused by the aged iron of the distributing transformer. The scheme of using the small independent transformers for reading the line voltage has much to commend it.

Determining the Power-factor of a Three-phase Circuit (By C. E. Howell).—Among men employed by operating electric companies there are many who know that methods exist by which the power-factor of a

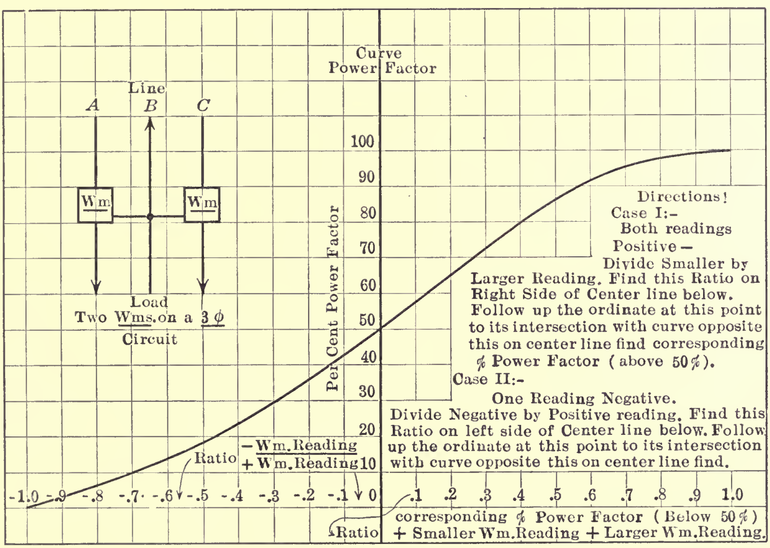


FIG. 1.—CHART OF INSTRUCTIONS.

three-phase circuit or installation may be determined, but comparatively few are able to apply them successfully. Many errors made in meter connections due to the effect of low power-factor on the registration of single-phase watt-hour meters (or wattmeters) or separate elements of polyphase meters on three-phase circuits are directly traceable to the lack of knowledge of the points brought out in the accompanying illustrations. Figs. 1 and 2 are copies of instruction sheets furnished by one operating company to its employees where induction-motor installations are the rule. These sheets have been reproduced here with the hope that some seeker after knowledge will be benefited. Fig. 1 in the well-known power-factor curve for two single-phase meters on a polyphase circuit. It also gives a small diagram of simple connections in addition to a few

words of instruction with reference to the use of the curve. As the figure stands it should be self-explanatory. Fig. 2 gives, first, a method of checking results obtained by employing the curve given in Fig. 1, as well as a diagram of the connections to be used in obtaining data for the check. This part of Fig. 2 should be easy to apply. The second part of Fig. 2 gives a detailed method of determining the correct connections of two single-phase meters, or one polyphase meter, on a three-phase circuit. If this part of Fig. 2 is employed with care errors in meter connections on three-phase circuits due to the power-factor being near 50 per cent. should be a minimum.

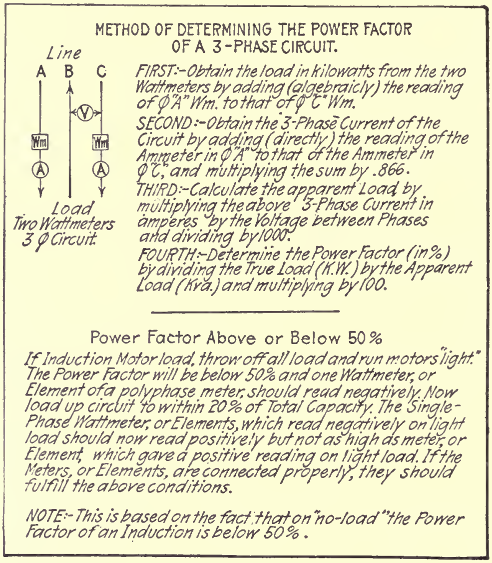


FIG. 2.—CHART OF INSTRUCTIONS.

To illustrate the use of the above instructions, an actual case will be taken: A 100-h.p., three-phase, 440-volt induction motor was operating on 30 per cent. full load or 40 h.p. (29.8 kw.) at 60 per cent. power-factor (afterward determined) when an order "came through" to place a polyphase meter on the installation. Immediately after the meter had been connected in circuit the following question was asked: "Should the light element add to or subtract from the heavy element; that is, is the power-factor above or below 50 per cent.?" As the meter leads were incased in pipe, these could not be traced, therefore the instructions in the second figure pertaining to this point were applied. The connected load of the motor having been thrown off, it was found that one element of the meter gave a negative reading. Sufficient load was then put on to bring the motor to about 80 per cent. of its full-load rating. Each element

of the meter (taken separately) now read positively, but the element which on no-load gave a negative reading on 80 per cent. load read lower than the heavy element. The meter had been correctly connected when installed. Later both methods given in the above figures to determine the power-factor of a three-phase circuit were applied and both gave approximately 60 per cent. (at 30 per cent. load), as previously stated.

Polyphase Feeder-regulator Motors Operated from Single-phase Feeder Circuit.—It is quite generally known that a three-phase motor operating on a single-phase system will supply three-phase energy at its terminals. The principle has been applied by the Kansas City Electric Light Company, of Kansas City, Mo., in one of its substations. During

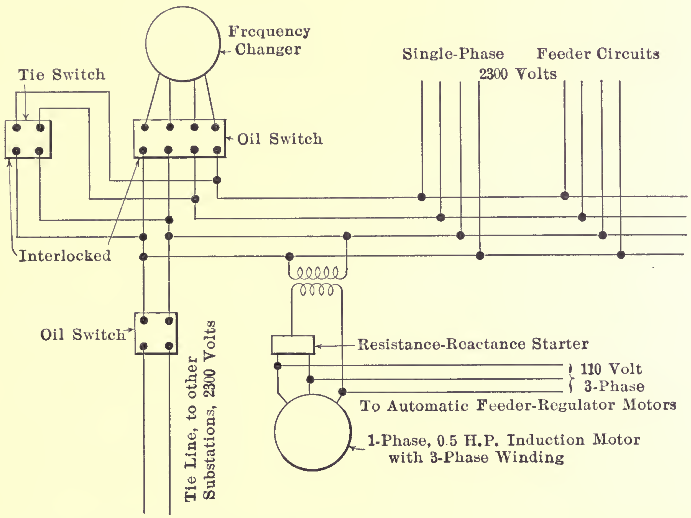


FIG. 1.—POLYPHASE FEEDER-REGULATOR MOTORS OPERATED FROM SINGLE-PHASE FEEDER CIRCUIT.

light loads the frequency changer in one of the electric-service company's substations is shut down, and single-phase energy is supplied over a single-phase tie-line from another substation. The frequency changer when operating supplies two-phase energy, which is distributed to single-phase feeder circuits in such a way as to maintain a balanced system.

As the automatic feeder-regulator motors require polyphase current for operation, an induction motor, connected as shown in the diagram, is employed to furnish three-phase energy when the frequency changer is shut down. Although rated as a 0.5-h.p. single-phase machine, the motor is equipped with three-phase windings. A step-down transformer supplies the energy needed for the motor. A resistance-react-

ance starter is connected between the motor and one of the low-tension terminals of the transformer for starting on single-phase energy. With the arrangement shown in Fig. 1 it would be possible to operate the apparatus from a distance.

Interchangeable Connections for Feeder Resistance.—In order to get the same pressure on direct-current mains near the station as in outlying sections supplied over comparatively long feeder lines, some engineers have actually gone to the point of carrying a 1,000,000-circ. mil cable half the length of one of the longer feeders and then back again to the mains near the station, in this way obtaining the desired drop in voltage. A scheme of making the feeder resistance adjustable inside the station itself is employed by the Kansas City Electric Light Company, which has made good use of some standard railway grid resistors in equipping a short heavily loaded feeder that terminates within 75 ft. of the station bus.

Securing the largest railway grid resistors to be had and neglecting their intermittent rating for car use, special tests made showed that these grids would carry 100 amp. continuously. Pairs of these grids were then permanently paralleled, and groups of fifteen such pairs mounted in racks,

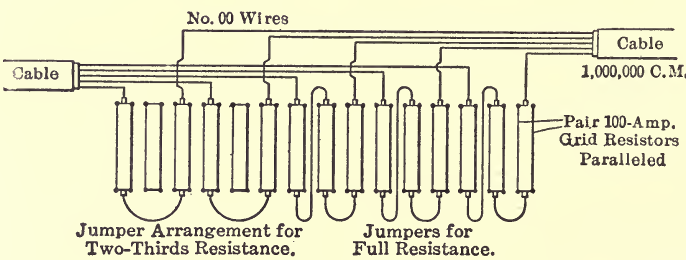


FIG. 1.—INTERCHANGEABLE CONNECTIONS FOR FEEDER RESISTANCE.

one thirty-grid group being provided for the positive side and a similar group for the negative, as Fig. 1 shows. By means of the jumper wires and lugs used with the diverter grids on the cars any adjustment from full to two-thirds of full resistance can be obtained. The arrangement of jumpers for these two conditions is illustrated. At full load the 75-ft. 1,000,000-circ. mil feeder thus equipped carries 1000 amp., and the drop across the resistance banks is about 10 volts. With all resistance in, the resistance of the grids about equals the resistance of 1000 ft. of 1,000-000-circ. mil copper cable, so that the terminal pressure on this short line is about equal to that on the other full-length feeders, the shortest of which is 1000 ft. The resistor grids are mounted in the basement of the Fifteenth Street direct-current substation without any special provision for carrying off the heat developed.

Rearrangement of Three-wire System to Reduce Voltage Fluctuations.—In a Kansas flouring mill operated by 220-volt, three-phase motors trouble was experienced with the flickering of the lamp circuits supplied from the same feeders as the motors. As first installed, the transformers were arranged to furnish 220-volt, three-wire service from a single phase of the three available. The 10-kw. transformers were provided with middle taps and these were first used as the neutral connections of the 110/120-volt, three-wire system for the lighting service. With the 15-h.p. motor fed from the same lines, the lamps flickered

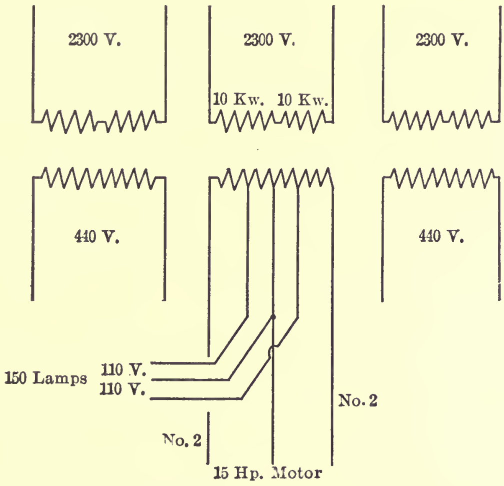


FIG. 1.—REARRANGEMENT OF THREE-WIRE SYSTEM TO REDUCE VOLTAGE FLUCTUATIONS.

badly each time the motor was started and stopped or underwent a change in load. Connections were then changed to the arrangement shown in the diagram, Fig. 1, the three-wire system being converted to 110/220-volt service, with the "outside wires" taken from new quarter points midway between the original neutral and the outside motor circuits. In place of the 220-volt lamps formerly used, 110-volt lamps were installed. The result has been the practical elimination of the flicker that was formerly so objectionable, probably owing largely to the fact that the low-voltage filaments have greater heat-storage capacity and thus are less sensitive to voltage variations than the 220-volt lamps.

Circuit with Shifting Neutral Improved by Installation of Autotransformer (By O. H. Hutchings).—A somewhat novel use was made of a standard lighting transformer by the writer to overcome a troublesome condition that developed in a village adjacent to Dayton, Ohio. The

village receives its electric service from the Dayton Power & Light Company, a local three-wire distributing system being supplied from one 25-kw. transformer centrally located. A moving-picture theater is located within the village at a point approximately 500 ft. from the transformer, the result being to displace the neutral at such times as the machine would be in operation, the machine taking its current at 110 volts. The first thought was to install an independent transformer at a point near the troublesome service, but this necessitated an extension of the 6600-volt primaries and did not seem justified. The plan adopted, which worked out satisfactorily, was to hang an independent transformer (5 kw.) on the pole from which this service connection was made and connect the secondary coil across the outer wires of the theater service. The neutral connection of the three-wire service, leading to the theater,

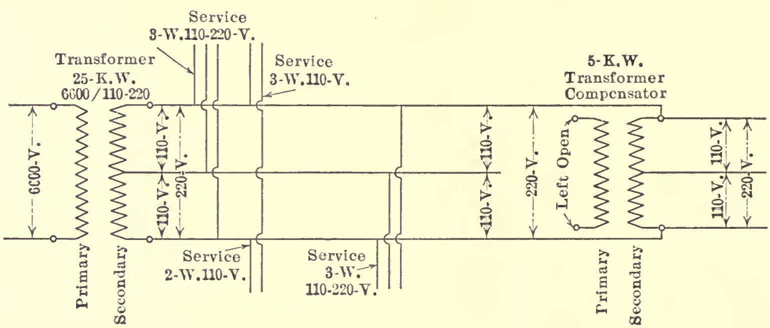


FIG. 1.—CIRCUIT WITH SHIFTING NEUTRAL IMPROVED BY USE OF AUTO-TRANSFORMERS.

was removed from the distributing lines and connected to the neutral point of the transformer secondary, using the transformer as a "compensator." The primary leads of the transformer were carefully taped on account of the higher voltage, the transformer being connected to "step-up." Tests upon this service after the installation of the transformer disclosed the fact that the equipment could be overloaded approximately 400 per cent. at 100 volts, with a neutral displacement of only 1 per cent. The diagram, Fig. 1, presents this scheme clearly.

Application of Tirrill Regulator to Adjust Balancer for Neutral Regulation at Distant Point.—The unbalancing action on the 110–220-volt Edison three-wire system of the Dayton (Ohio) Lighting Company is unusually severe owing to the presence on the lines of several large 110-volt elevator motors. A 90-kw. balancer set is provided to adjust the voltage differences on this direct-current system, the load on which varies from 1000 kw. to 1800 kw. This balancer has its fields adjusted by a Tirrill regulator, the control of which can be effected from any one of

fourteen sets of pressure wires brought back from as many points in the downtown network, so that the neutral pressure can be kept practically constant at this given point, regardless of the load on the lines or the pressure at the station. Several other means were attempted in the effort to solve this voltage variation, the severity of which was such that use of a three-wire generator had to be abandoned except as a 220-volt machine feeding into the outers. The present application of the Tirrill regulator principle is due to O. H. Hutchings, general superintendent of the Dayton system, and has resulted in practically perfect regulation. The opposed-voltage relay, energized through pilot wires from the point on the network regulated for, closes in the corresponding direction when either side drops in pressure, operating one of the contact switches

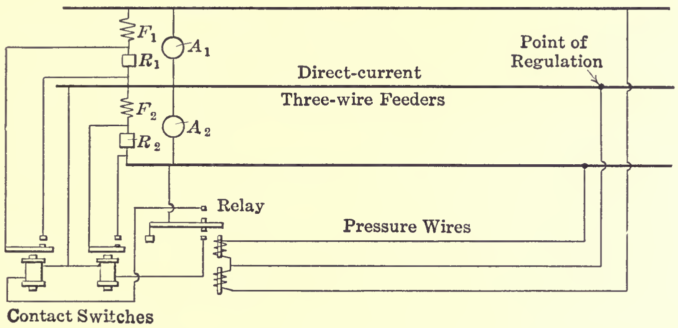


FIG. 1.—APPLICATION OF REGULATOR TO ADJUST THREE-WIRE BALANCER FOR DISTANT POINT IN NETWORK.

which short-circuits the corresponding field rheostat, boosting the pressure on that side. As the result, a very close voltage regulation is obtained on the downtown network, regardless of the varying unbalanced loads.

Where pressure wires are not available, it may be suggested that a similar regulation for a distant point could be obtained with apparatus entirely within the station by using differentially wound relay coils, having one winding across the mains at the bus and the other bridged across a shunt in the outgoing feeders, in this way obtaining an artificial subtractive action for the drop in the feeders.

Arrangement of Tirrill Regulator to Compensate over Adjustable Range of Terminal Pressures (By L. S. Smith).—When a Tirrill field regulator is arranged with compensating elements to deliver a uniform pressure at the distant end of a transmission line, regardless of load, it is sometimes desirable to raise or lower the delivered voltage, depending on the regulator to maintain this new voltage value constant. The 5000-kw. steam plant of the Pueblo (Col.) Traction & Lighting Company transmits to distant substations at which it often becomes desirable to raise the

pressure beyond the value normally held by the generator regulator. Without disturbing the compensating resistance and reactance settings on the regulator, this is accomplished by inserting a rheostat in series with the alternating-current magnet. The rheostat, as built by Mr. M. G. Lord, of the Pueblo plant staff, for use with a Tirrill regulator, comprises 50 ft. of No. 22 German-silver wire tapped out to ten contact points on a face plate. This little rheostat thus permits a total range of about 20 per cent. of the delivered pressure, the latter voltage being held constant as before at any value for which it is adjusted. Fig. 1 shows the layout.

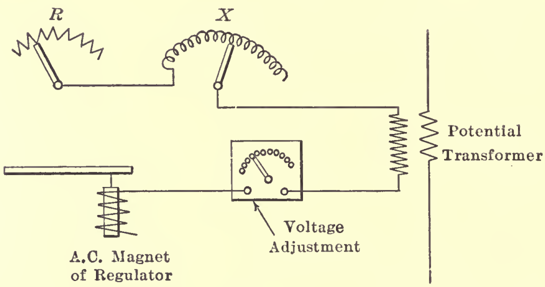


FIG. 1.—ARRANGEMENT OF TIRRILL REGULATOR TO COMPENSATE OVER ADJUSTABLE RANGE OF TERMINAL PRESSURES.

Voltmeter Test Boxes at Distribution Points.—At each of the thirty distributing centers of its alternating-current system the Kansas City Electric Light Company has made provisions for getting graphic records of the voltage regulation obtained. Special 1-kw. transformers at each of these distinguishing-point poles have their secondaries wired down to connection clips in a permanent instrument box mounted on the pole 6 ft. above the ground. The interiors of these boxes have rests to hold standard portable curve-drawing voltmeters, which can be connected up and thus left in position to draw their own records twenty-four or forty-eight hours at a time. The boxes are covered with sheet metal and are provided with stout padlocks to protect them against tampering. They are also well up and out of the way of pedestrians, but can easily be reached by the instrument man with the aid of a chair or box. With the aid of the station instruments corresponding to the same feeds, a close check is obtained on the compensation necessary for each feeder's regulation.

V

SWITCHBOARDS AND POWER HOUSE DETAILS

Installation, Metering Power, Remote Control Circuits, Interruption Records, Testing, Synchronizing Bank, Etc.

Supporting Cables in Vertical Runs (By C. L. Wilson).—The accompanying Fig. 1 shows a method for supporting 1,000,000-circ.-mil cables in undergoing a vertical rise of about 50 ft. The circular clamping blocks are turned out of maple and afterward paraffined thoroughly. The inner opening of the blocks is given a diameter the same as the cable itself at one end, tapering slightly to a larger diameter at the upper end. U-bolts threaded on each leg and locked to the angle-iron framing with nuts serve to clamp the blocks together on the cable. An annular recess is grooved on the outside surface of the blocks to receive this metal

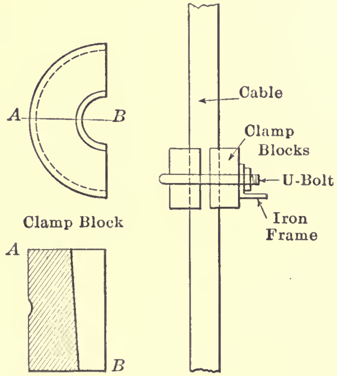


FIG. 1.—CLAMPING BLOCK FOR SUPPORTING VERTICAL CABLE.

shank. As shown in the magnified diagram, the blocks are placed with the inside taper so arranged as to grip the cable all the tighter under the weight of the cable itself or should there be any tendency for it to slip. This little "kink" of the inside taper will be found well worth the trouble, for it secures a rigid stationary position of the cable, insuring a construction that will not sag.

Casting Bolts in Concrete Walls (By A. McCarty).—In mounting high-tension switches, busbar frames, barrier slabs and other parts on concrete walls the job will be far more permanent and workmanlike if

during the pouring of the concrete the bolt studs are cast directly into the wall material itself. This can best be done as shown in the accompanying Fig. 1, in which template holes, at the distances and positions of those in the future fitting, are shown bored in the form used to mold the concrete. Then through these holes are clamped the bolts, inclosed in pieces of pipe a little larger than their own diameter, and having their far ends bent into a partial hook, against which to tighten the nut. When the concrete has hardened and the forms are removed, the cleanly threaded bolts are left firmly imbedded in the wall in position for the attachment of fittings. The purpose of using the pipe to inclose the bolt is to allow a little play of the bolt for slight variations in the distances

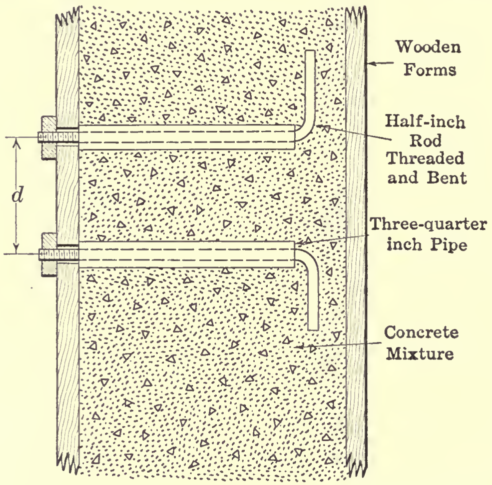


FIG. 1.—CLAMPING BOLTS IN CONCRETE WALLS.

between holes in the templates or fittings. If a 1/2-in. bolt is inclosed in a 3/4-in. pipe an adjustment of 1/4 in. is possible at each bolt, the shank being easily sprung into the position desired. The pipe also forms a shoulder against which to lock the form template when clamping on the nut before pouring the form.

A Method for Bending Busbars (By J. Cloyd Downs).—The writer has had much work to do on various sizes of copper busbars. As far as possible, lengths of approximately 20 ft. were used as, of course, the longer the individual bars the smaller the percentage will be that is wasted in the laps. Copper busbars of this length are quite difficult to handle and to bend with any degree of accuracy without special apparatus. In doing this work the writer has found a comparatively easy and simple way to bend the busbars. This consists in using a piece of timber about 6 in. or 8 in. and perhaps 16 ft. long, and arranging

a clamp at one end made up of a piece of flat iron and a couple of bolts passing through the timber. The busbar is secured under this clamp within about 2 in. of where the bend is desired, and a pinch bar is clamped to it as shown in the accompanying Fig. 1. With this apparatus the busbar can be bent with a fair degree of accuracy to any angle desired. Before making a bend a wire can be bent to the correct angle and then used as a templet in bending the busbar. To put a quarter twist in a busbar, the latter is clamped and a pinch bar is clamped to it at right angles to the length of the busbar and the busbar twisted. In a 2 1/2-in. by 1/2-in. copper busbar a quarter twist can be made in

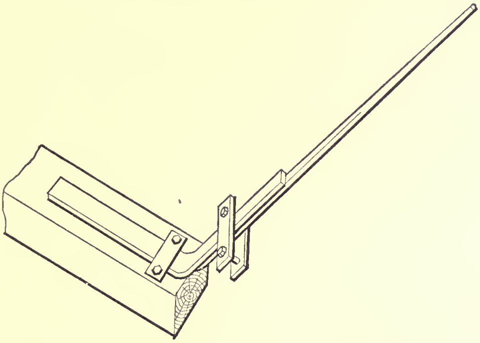


FIG. 1.—A METHOD FOR BENDING BUSBARS.

about 6 in. of length without forging. A short bar can probably be handled to better advantage in a vise. To bend a bar on its edge it is generally necessary to send it to a forge shop and to make the bend while the bar is hot, since it is difficult to make the busbars stay flat otherwise.

A Switchboard Wiring Pit (By Edgar M. Thurber).—Wiring around switchboards in stations of small capacity is not always as neatly and systematically installed as it might be. Frequently the feeder conductors are brought to the board from above and even if they are neatly arranged they obstruct the light and constitute a lodging place for dust. Leads from generators usually are carried in ducts beneath the station floor and rise to their lugs on the switchboard panels from below. This is a neat arrangement and it at once suggests to the small-station designer that, under favorable conditions, it is best to bring all conductors to a switchboard from below rather than from above.

When circumstances are such that it is feasible to bring wiring to panels from below it can readily be arranged for in buildings not having basements through the construction of a "wiring pit" like that in Fig. 1, page 92. The pit is excavated to a depth of from 4 ft. to 5 ft. at the time the building is erected. It has, in the example shown, brick walls

and a concrete floor. In Fig. 1 the conductors from the generator and the exciter sets are conveyed, in wrought-iron conduit, beneath the floor, from the machine terminals to the wiring pit. Four feeders (Fig. 2) enter the pit through vitrified underground conduit and three more enter from above through vertical wrought-iron conduits secured to

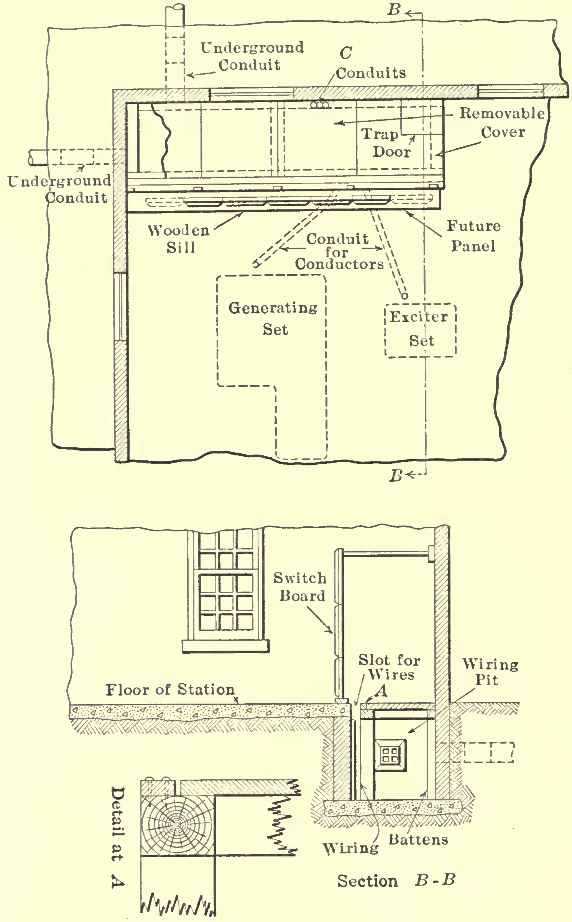


FIG. 1.—WIRING PIT BACK OF SWITCHBOARD.

the face of the station wall with pipe straps. Within the wiring pit all of the conductors are supported in porcelain cleats, held on wooden battens arranged on the pit walls, as illustrated in Fig. 3. The cleats (see detail in Fig. 3) are of the single-wire, split type and are clamped into position with wood screws. The battens are secured to the pit walls with lag screws turning into wooden plugs inserted in the brickwork.

A temporary floor, shown in Fig. 1, is provided over the pit. It

consists of sections of such size that they can be readily handled. These sections are supported on a timber framework (Fig. 1). A trapdoor is located in one corner, so that the pit can be entered without the necessity of removing an entire floor section. A slot, extending the entire length of the pit, at the side adjacent to the switchboard, permits the conductors

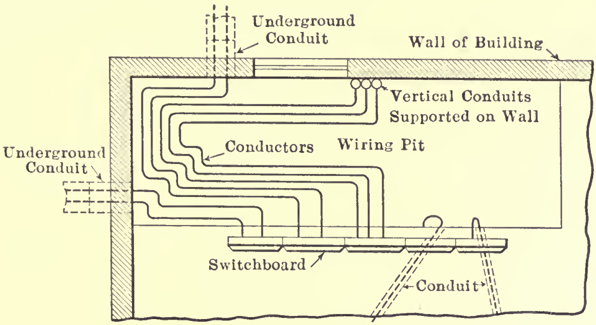


FIG. 2.—ARRANGEMENT OF WIRING IN PIT.

to be carried vertically upward to their respective lugs on the panels. As indicated at detail "A," Fig. 1, a strip is nailed along the edge of the section-supporting timber to retain the floor sections in their proper locations.

In Fig. 4 is shown the method used in constructing the entrances

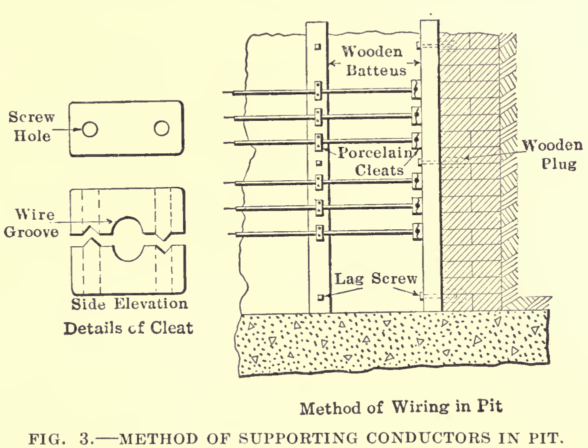


FIG. 3.—METHOD OF SUPPORTING CONDUCTORS IN PIT.

of the underground conduits. The vitrified conduit extends only about half through the wall and a portion of the inner wall is chamfered all around at an angle of about 30 deg. to meet the edge of the conduit. The wall face is thus formed so that the conductors entering the pit through the conduit will not have to be bent sharply where they leave

the conduit, as they would have to be if the end of the conduit length were flush with the true inner surface of the wall. Sharp bends must be particularly avoided where lead-sheathed conductors are involved. Where the wrought-iron conduits conveying the generator and exciter leads enter the pit the wall is similarly recessed, as detailed in Fig. 5.

In arranging the wiring within the pit all conductors should be carried around the walls, as shown in Fig. 2; none should be permitted

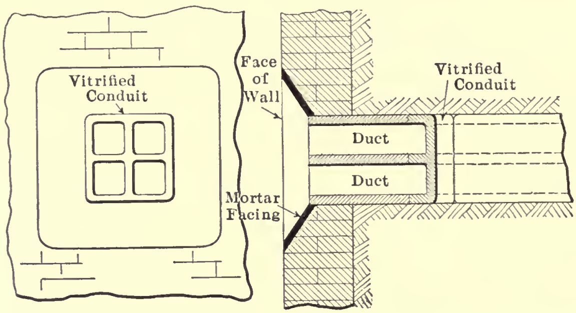


FIG. 4.—WALL FACE AT VITRIFIED CONDUIT ENTRANCE.

to cross it, except at the ends. This procedure will involve more copper than if the most direct route is selected in each case, but it will doubtless be the most economical in the long run, because it will insure ease of inspection and will leave practically the entire pit unobstructed. There should always be ample room in a pit for the wiremen and for the tackle used in drawing conductors into the conduits.

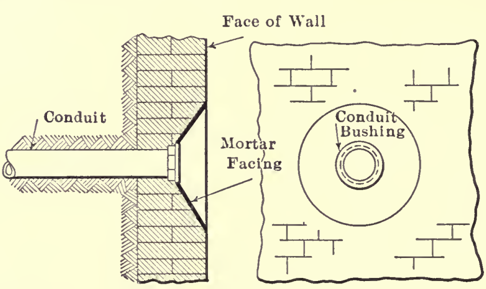


FIG. 5.—WALL FACE AT IRON CONDUIT ENTRANCE.

Colored Wire for Switchboards and Panels.—Colored-braid wire is now standard for switchboard-instrument connections in the stations of the Kansas City Electric Light Company and for meter circuits in its customers' installations. Red, blue, brown and yellow are used to indicate various phases, etc., No. 12 being specified for series-transformer connections and No. 14 for voltmeter connections. The same color of wire is in each case associated with the same phase for both series and

shunt connections, so that when connecting up a polyphase meter it is a simple matter to bring similar colors to similar phase binding posts. On any given switchboard or customer's panel the nomenclature is identical throughout. The same rule does not hold between different installations, but the order of phase rotation, which is of chief importance, is always the same for all boards on the system. Black is used for the common return unless there is a third wire, in which case this phase receives a yellow wire. Manufacturers furnish this colored wire at a cost about 10 per cent. in advance of regular wire prices. The scheme is shown in the diagram, Fig. 1.

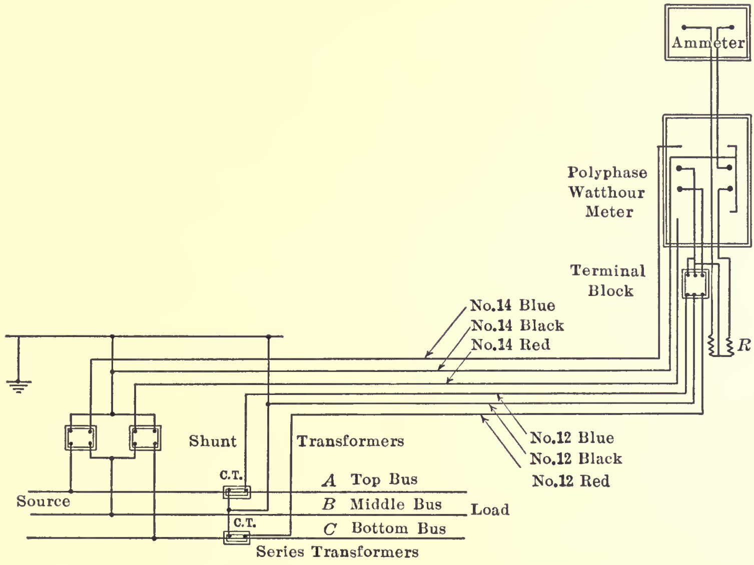


FIG. 1.—COLORED WIRE FOR SWITCHBOARDS AND PANELS.

Connection Board for Metering Power.—The diagram, Fig. 1 on page 96, shows an improved arrangement for reading the current in three lines using only one ammeter, as well as for reading three-phase watts with only one single-phase wattmeter. The board is "fool-proof" when properly wired up, and it is difficult to make an error in connections. No interlocking mechanical parts are necessary. The number of special pieces required is reduced to a pair of raised clips which convert the double-pole switch into a triple-throw connection. The three single-pole switches serve as line switches and as ammeter-short-circuiting switches.

If the three lines coming from the source of power are connected to the three terminals at the top of the board and the load is connected to the three terminals at the bottom, the circuit is closed by using the three

single-pole switches. The current in the left line is read by connecting the ammeter to the two terminals at the side of the board and closing the main switch to the left. Opening the left single-pole switch allows the current in this line to pass through the meter. Next, by closing the single-pole switch, moving the main switch to a position vertical to the board so that it makes contact with the raised clips, and opening the middle single-pole switch, the current in the middle line can be read. For the current in the third line, close the last single-pole switch, move the main switch to the right and open the right-hand switch.

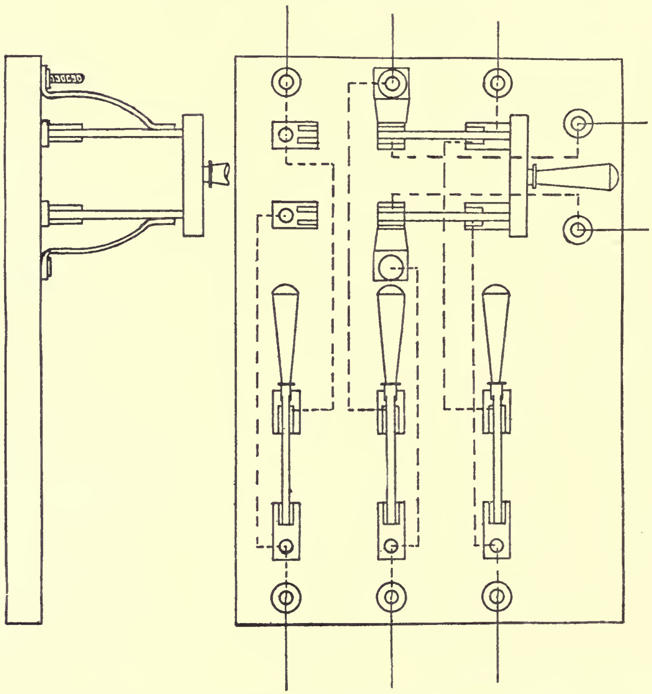


FIG. 1.—CONNECTION BOARD FOR METERING POWER.

To measure power with a single-phase wattmeter, the current coil of the instrument is connected in series with the ammeter, and one end of the potential circuit is led to the middle terminal at the top of the board. The other potential terminal of the wattmeter is then led to the left-hand or right-hand line corresponding to the one in which the current coil is connected. The sum of the two readings gives the total power being transmitted. No wattmeter reading is, of course, taken with the current coil in the middle line. When the power-factor is less than 50 per cent. the smaller wattmeter reading will be negative and should be subtracted from the larger.

The connections indicated by the dotted lines are made on the back of the board. Equipped with 60-amp. 125-volt switches and suitable terminal posts for the external connections, the board measures 12 in. by 20 in.

Connections for Obtaining Feeder Voltage Records.—The switch structure of the turbine station of the Laclede Gas Company, St. Louis, has a double bus, and in the office of the electrical engineer, Mr. William Bradford, are corresponding duplicate recording-instrument panels, each with a Bristol recording voltmeter, General Electric curve-drawing wattmeter and totalizing kw.-hr. meters. As only one bus is commonly used in operating, the instruments on the other are available for studying individual feeder conditions. For taking voltage curves of each of the ten single-phase feeders Hubbell push sockets have been mounted on the rear of these panels. Suspended from the switchboard braces and running the length of the feeder panels is a conduit line with condulet fittings inclosing similar push sockets opposite the panel sockets. A double-ended prong-plug jumper serves to make the connection between panel and conduit sockets. The conduit line ends in a connection to the regular voltmeter plug, so that a continuous record can be secured of any feeder by plugging from the voltmeter to the corresponding panel socket.

Alarm to Indicate Operation of Remote Rectifier Set.—Two of the seventy-five lamp, 4-amp. magnetite-arc rectifier sets in the Vandevanter

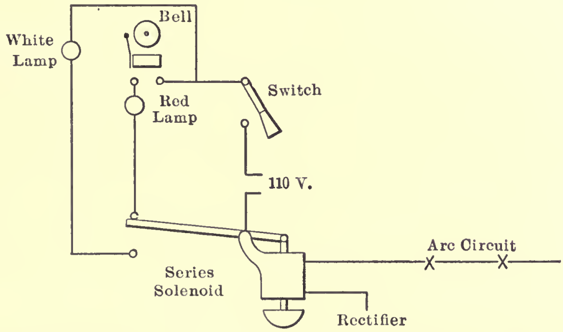


FIG. 1.—ALARM TO INDICATE OPERATION OF REMOTE RECTIFIER SET.

substation of the Union Electric Light & Power Company, St. Louis, had to be mounted in the basement on account of lack of space on the main operating floor. Since the station operator could not make sure that the rectifiers were working properly without running up and down stairs at intervals, W. A. Yandell, in charge of substations, arranged the series-solenoid alarm circuit of Fig. 1. As long as the rectifier operates properly the white lamp is lighted. If the arc circuit is interrupted the

contact arm drops to the bell circuit, at the same time lighting a red lamp as a visual warning. At the St. Charles Street substation, where a number of rectifiers are banked together closely, the series solenoids of the tube circuits are arranged to ring an alarm bell in case of any interruption. If an arc forms between the auxiliary electrode of the tube, short-circuiting and causing danger of overheating of the exciting transformer, the alarm is similarly sounded.

Alarm Circuit for Double-throw Oil Switches.—The switchboard of an Eastern power house was recently rearranged to provide for duplicate buses onto either of which the generators could be thrown by means of pairs of interlocked oil switches. Later a circuit-breaker alarm and

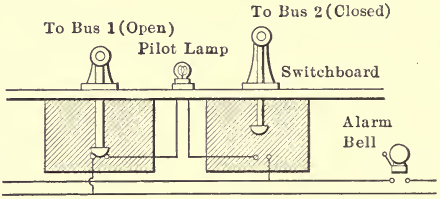


FIG. 1.—ALARM CIRCUIT FOR DOUBLE-THROW OIL SWITCHES.

pilot-lamp scheme was applied to the single-throw switches on the board, so that upon the opening of any breaker a bell would ring and a lamp on its panel would be lighted. To extend this system to the double-bus section caused the station wireman some worry, because one switch or the other of each interlocked pair would be open at all times and yet the bell must ring if for any reason the closed member opened. The difficulty was solved (see Fig. 1), double contacts being provided at each switch and the pair connected in series. The oil switch which is open has its own signal contacts closed. Opening of the other switch closes its contacts and thus, completing the circuit, sounds the alarm.

Remote Control of Circuits (By D. E. King).—The upper Fig. 1 on page 99 shows a simple device, reliable as well as inexpensive, for the remote control of either primary or secondary circuits. The write-prefers this scheme to solenoids or carbon break switches. The three-phase motor is fed from a No. 14 wire at a potential of 220 volts, the distance from the office to the switch being a quarter of a mile. The oil switch connects the 2300-volt primaries with two series transformers, used for street lighting, and to reverse the direction of rotation of the motor, to throw the circuit on or off, a two-pole, double-throw switch is used. The center leg of the motor is always in circuit and when the switch is thrown in one position two of the phases are reversed. In the other position the connections are normal.

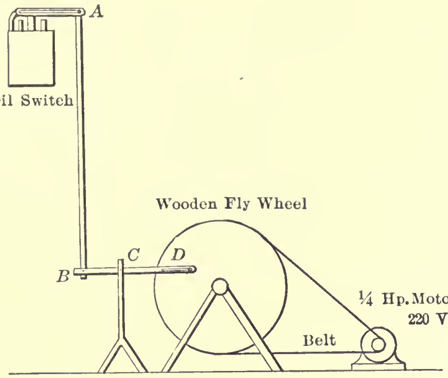


FIG. 1.—REMOTE CONTROL OF CIRCUITS.

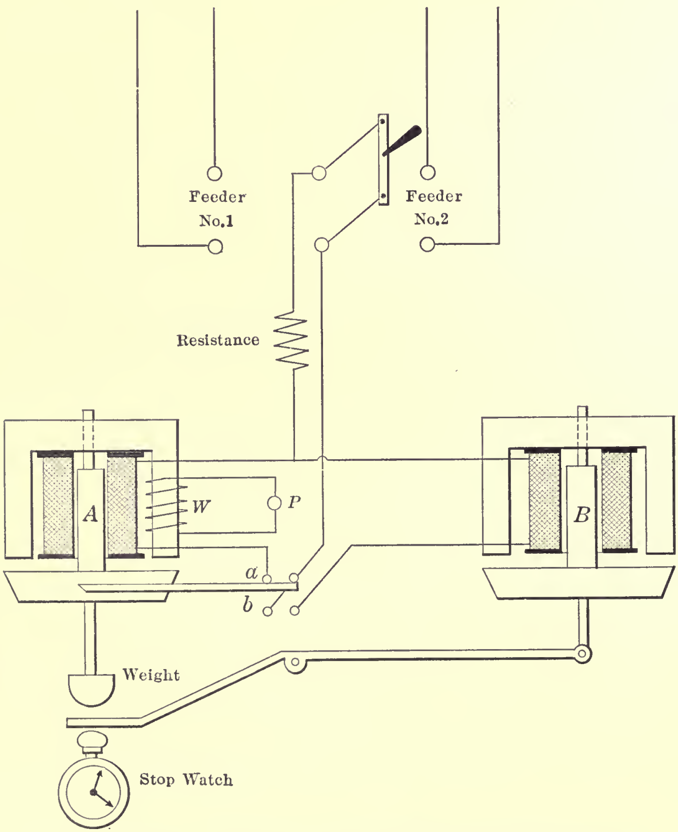


FIG. 1.—STOP-WATCH RECORD OF SERVICE INTERRUPTIONS.

Stop-watch Record of Service Interruption.—The lower Fig. 1 on page 99 shows a pair of relays and a stop-watch, which preserves an accurate record of the time the voltage is off the system. A device of this kind is now being used by the Yonkers (N. Y.) Electric Light & Power Company. Ordinarily, the relay *A* is in circuit, and it remains excited as long as potential is on the feeder. In case of an interruption *A* is de-energized, allowing its weighted armature to drop and deliver a slight blow on the stem of the stop-watch, setting the timing hand in motion. Incidentally the fall of the armature disconnects at *a* the circuit to relay *A*, bridging, instead, the relay *B* across the dead feeder. When service is restored *B* picks up, and its armature in closing presses on the watch stem through the crank arm, this time stopping the moving hand. Service interruptions are thus recorded with an accuracy down to one-fifth of a second. A small pilot lamp, *P*, burns as long as relay *A* is in circuit, thus indicating at a glance that no service interruption has yet occurred. This little 2.5-volt lamp is supplied with energy from secondary windings wrapped on the frame of relay *A*. An ordinary 8-c.p. lamp is used as resistance in series with the relays. By means of the double-pole double-throw switch, the recording device can be connected to either one of two feeder lines which it is desired to supervise. A pair of springs hold the stop-watch in place, minimizing jarring and helping to receive the blows of the falling weight and the relay movement.

Field Excitation Test Lamps.—A useful adjunct to the operating equipment of a large Western turbine station is a bank of lamps and

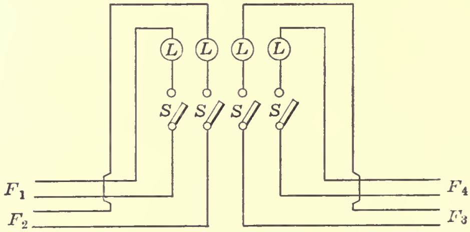


FIG. 1.—FIELD EXCITATION TEST LAMPS.

switches by means of which the floor attendant can determine at any time which machines have their fields excited. The small lamps of the bank, which is mounted on a pedestal at the center of the turbine room, are each connected in parallel with one of the turbine fields, and by closing its corresponding switch momentarily the operator can test to find on which units the excitation switches are closed. The scheme is shown in Fig. 1.

Circular Synchronizing Bank (By F. G. Falloon).—The following view. Fig. 1 explains the connections of a simple synchronizing

bank made of twelve ordinary 110-volt lamps with the necessary sockets and wiring. If the incoming machine is below speed, full voltage will revolve about the circle to the left. If the machine is above speed, full voltage will revolve to the right. When both machines are near synchronism the two opposite points of the diamond will come to full voltage, followed by the remaining two points. When all four points are at full voltage the machine is in synchronism.

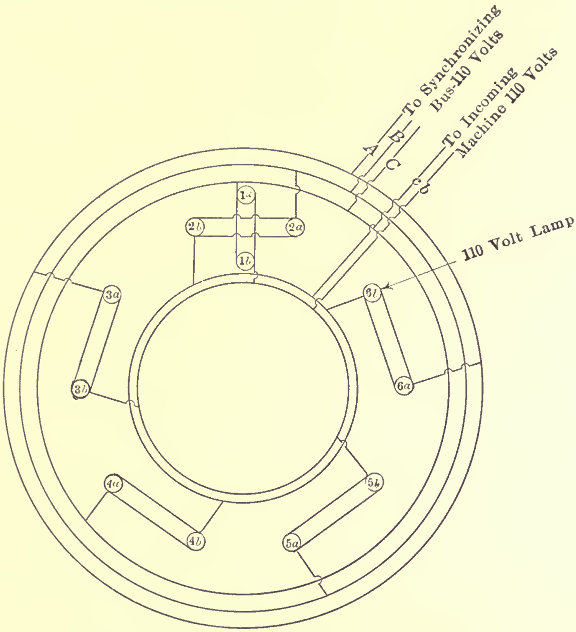


FIG. 1.—CIRCULAR SYNCHRONIZING BANK.

Relay Auxiliary Contact For Aluminum Check Cell.—The exciter bus is connected to the operating bus in Sub-station No. 5 of the Union Electric Company's system, St. Louis, through a reverse-power circuit-breaker which opens in case of any reversal due to shutdown of the 5-h.p. motor-generator set commonly energizing the combined 125-volt bus. Bridged across the operating bus is also an 80-amp. storage battery, provided for operating the oil switches in case of interruption of direct-current supply. This battery is arranged with an aluminum-iron check cell containing six aluminum and seven iron plates in a 10 per cent. solution of boric acid. The check cell alone operates very satisfactorily in preventing flow of energy in the reverse direction, but was found to introduce about 5 volts drop when passing current normally. This loss, which occasioned local heating, has now been prevented by adding a relay with contacts closing across the check cell. For reverse-direction

currents the circuit is still open as before. But when the check cell admits current in the normal direction the relay winding is thereby energized, closing the path around the cell. The relay remains closed as long as energy is being drawn from the battery, dropping out again when the current falls below the value necessary to hold up its armature. The scheme is shown in Fig. 1.

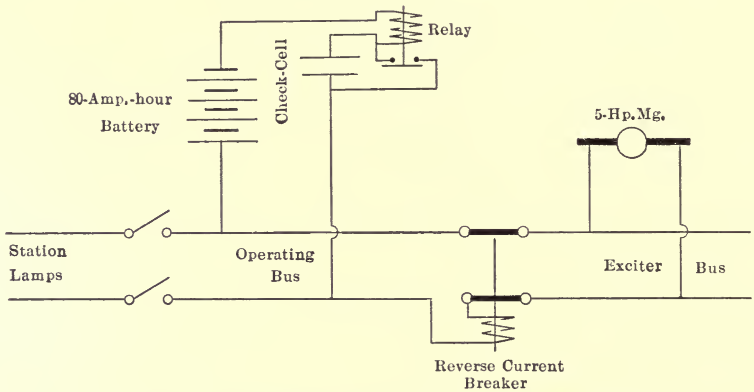


FIG. 1.—RELAY AUXILIARY CONTACT FOR ALUMINUM CHECK CELL.

Balancer Set used to bring up Low Battery Cells.—A central station supplying energy to a 110–220-volt Edison three-wire system uses a pair of 50-kw. machines coupled together, for operating as a balancer set. The same station also contains a storage battery with a rating of 1200 amp.-hr. To give low cells special charges without disconnecting them from the main battery operation, this pair of balancer machines proves very useful when run as a motor-generator set. The machine used as a generator is carefully insulated from ground and all other parts of the system, and can be connected to a pair of No. 0 copper leads extending overhead the length of the battery-room. Jumpers with clip connectors are used to join this charging circuit to the terminals of the cell or cells to be treated, copper strips being clamped onto the lead webs to insure good contact. With this arrangement any cell or group of cells can be put through a cycle of charge without disturbing its connections or the operation of the main battery.

Disconnect Switch for Feeder Regulators.—In a turbine plant having its lighting feeders equipped with induction-type regulators use is made of disconnect switches, like Fig. 1, page 103, to cut the regulators clear of their circuits so that they may be repaired or inspected. There are three single-blade hook-type switches mounted on a common slate block each over its corresponding regulators. When the two outer blades are closed the regulator winding is in series with the line. To

disconnect the regulator, its rotor is first brought back to zero, to avoid short-circuiting any incremental voltage, and the middle blade is then closed. Opening the outer blades finally disconnects the apparatus altogether, rendering it "dead." Meanwhile the feeder may continue in uninterrupted use.

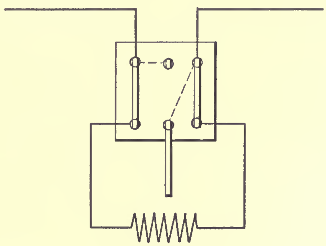


FIG. 1.—DISCONNECT SWITCH FOR FEEDER REGULATORS.

Extra Eye Lugs for Disconnect Switches.—In a certain railway substation the converting equipment consists of three 500-kw., 600-volt rotaries supplied through step-down transformers from a pair of 25,000-volt transmission lines. These supply connections are in duplicate, so that if one line breaks down the load can be transferred to the other by means of a double set of disconnecting switches. The switches have double blades, the holes for the puller hook being drilled through two blades.

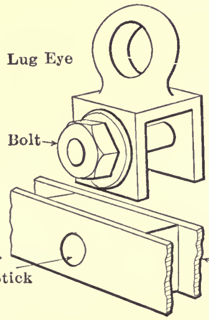


FIG. 1.—EXTRA EYE LUG FOR DISCONNECT SWITCHES.

The operators, however, experienced difficulty in finding the holes quickly when necessary, so the extra eye lugs, Fig. 1, were added. Without changing the switch blades in any way, this lug fits over the blades and is secured by the threaded bolt passing through the original hook-hole in the blades.

8

Iron-pipe Construction in Distribution Rack.—During a general rehabilitation of the plant of the Elwood (Ind.) Electric Light Company the distribution rack which carries the outgoing lines for local lighting and motor service was reconstructed. The feature of this rack reconstruction has been the use of 3-in. iron pipes with porcelain insulators fastened between them by means of bolts, giving to the finished structure a neat appearance combined with a degree of stability and endurance not possible to obtain by the use of wooden supports. Wires are brought out from the insulators in the wall of the station to the two lower pipes and are there dead-ended. Jumper wires are thence run to the insulators suspended from the pipe above and after making a right-angle turn at this point are taken to the lead which they are to supply. Throughout the installation white, brown, blue and yellow insulators have been used to distinguish respectively primary circuits, secondary circuits, arc-lamp circuits and grounded wires so that a man working on the rack has little trouble in distinguishing the several classes of lines.

VI

SIGNS, DISPLAY LIGHTING, SPECIAL APPLICATIONS

Operation, Installation, Protection of Signs, Show-window Lighting, Photography, Etc.

Remote-control Switches for Flat-rate Signs.—The Topeka (Kan.) Edison Company operates a number of flat-rate signs, turning these on at dusk and off at 10 o'clock, except Saturday night, when they are burned until 11:30 p. m. When controlled and switched by hand, as formerly, the company received the usual complaints because one sign was turned on before another or off before some one else, as the patrolman progressed on his rounds. This unavoidable dissatisfaction is now ended and the wage of the patrolman, $20 per month, is saved by switching all the signs from a central point by means of electromagnet contactors.

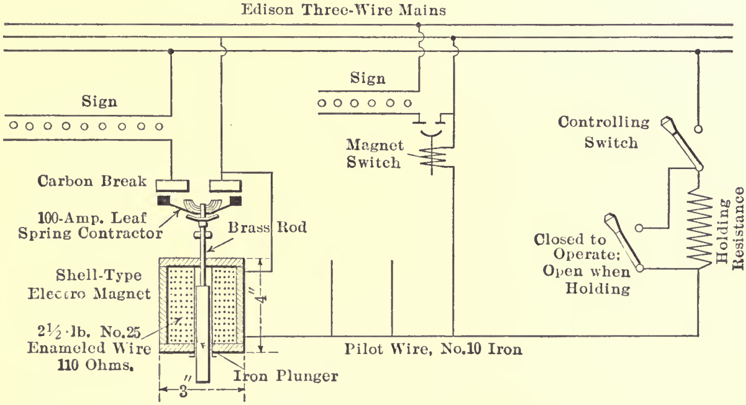


FIG. 1.—REMOTE-CONTROL SWITCHES FOR FLAT-RATE SIGNS.

Shell-type electromagnets are used in the switches, the outer dimensions of the magnetic-return casing being 4 in. long by 3 in. in diameter. The plunger has 1-in. travel in the 1-in. brass tube in which it slides. Two and one-third pounds of No. 25 black enameled magnet wire are used in each coil. A brass rod connects the plunger with the leaf-spring contactors, which are supplemented by carbon blocks to take any arcs that form on breaking the circuit. J. E. Gossett, electrical foreman, who

laid out the scheme, estimates the cost of these magnet switches to be about $6 each.

Extending through the business district is a No. 6 iron pressure wire which is used as the pilot circuit and tapped in multiple to the magnet windings. Each coil has a resistance of about 110 ohms and at 110 volts takes 1 amp. which closes the contact vigorously. A smaller current will hold the plunger in the closed position so that the control point is provided with a predetermined resistance which can be inserted in the pilot circuit after the switches have been closed, reducing the current per coil to 0.5 amp. This is ample to hold the contacts in position. As shown in Fig. 1, to light the signs the controlling switch is closed, the resistance switch having already been closed. The latter is then opened, inserting resistance to cut the holding current down to normal value so that the magnets will not heat. A master clock switch controls the sign circuits, avoiding all hand manipulation. Fifteen large signs are now operated by the Topeka pilot-wire circuit, which is nearly a mile in length.

Interchangeable Illuminated Sidewalk Sign.—The accompanying Fig. 1, shows a simple interchangeable electric-lighted sign to be seen in front of a Kentucky moving-picture theater where the bill is changed

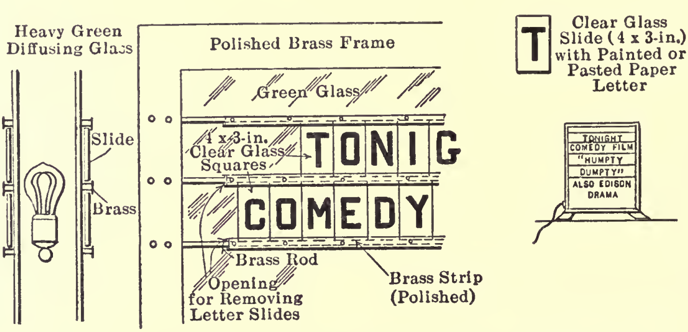


FIG. 1.—INTERCHANGEABLE ILLUMINATED SIDEWALK SIGN.

nightly and the sidewalk announcement must be varied with equal frequency. There are two 2-ft. by 3-ft. panes of heavy diffusing green glass, mounted together in a polished brass frame with sufficient interval to admit the half-dozen lamps which light the display. Across the glass panes on each side are fixed brass rods, and extending to within about 4 in. of the brass frame on the edges polished brass strips are fastened to these rods, forming slide-ways. In these grooves are placed the 3-in. by 4-in. clear-glass slides on which are painted the individual letters. If preferred, paper letters can be pasted onto the glass slides and used interchangeably to make up the words. The lamps inside the

sign are lighted through an extension cord, and the display presents a brilliant appearance lighted from both sides.

Running Boards for a Tungsten Lighting Installation (By Charles H. Wales).—A tungsten lamp installation was laid out for a building, shown in the sketch, Fig. 1. With the best arrangement of lighting units it was found that one row lay directly under a large galvanized-sheet-iron, hot-blast, heating duct. At first this was considered a serious obstacle and a rearrangement of the units was considered, but

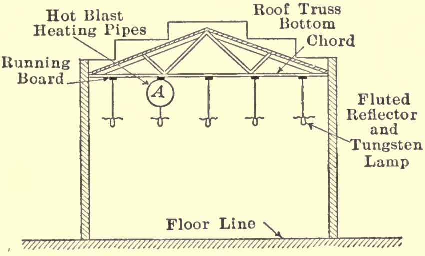


FIG. 1.—SECTION THROUGH BUILDING.

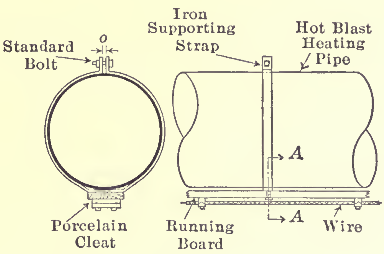


FIG. 2.—METHOD OF SECURING RUNNING BOARD TO PIPE.

the scheme indicated in Fig. 1 and detailed in Figs. 2 and 3 was finally adopted and has given entire satisfaction.

All of the conductors were supported on porcelain cleats, which were attached to running boards similar to that shown in Fig. 4. A running board was clamped to the bottom of the heating duct with a wrought-iron strap. The middle of each strap (see Fig. 3) was flattened for a distance equal to the width of a running board and drilled and countersunk for 1 1/2-in. flathead stone bolts. One of these straps, which had previously been bent to a circular form, the circle having an

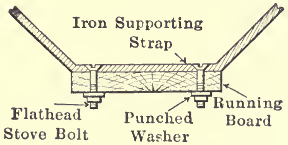


FIG. 3.—SECTION "AA" OF FIG. 2.

internal diameter the same as that of the outside of the heating pipe, was bolted to a running board every 10 ft. Ears, as shown in Fig. 2 were formed at the ends of the straps, and holes drilled therein through which the clamping bolts were inserted. The porcelain cleats were fastened, but not set up tightly to the boards before they were raised to position. The straps were so designed that the distance *O*, Fig. 2, was about 1 in. after the bolts had been set up snugly.

Boards and straps were raised to position and clamped to the pipe,

the wires run and the rosettes put on. The length of drop cord, from rosettes on the running board on the pipe, was made as short as possible, as it was desirable to have the lamps hang high. Drop cords from the other running boards, attached directly to the roof truss chords, were made of such a length that the lamps which they carried were the same distance from the floor as those supported by the running board on the heating pipe. This was done to insure an appearance of uniformity and to prevent objectionable shadows being cast by the hot-blast pipe.

In Fig. 4 are shown details of the running boards which were attached directly to the roof trusses and of the fittings used in making the attachment. The distance between centers of roof trusses was so great that

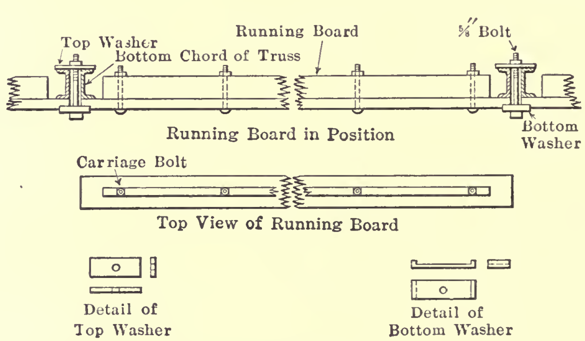


FIG. 4.—DETAILS OF RUNNING BOARDS AND FITTINGS.

a single plank was not sufficiently stiff to carry the wires and fixtures without excessive deflection. Accordingly, each board was reinforced with another plank, which was clamped to the first with carriage bolts. The second was arranged vertically as indicated in Fig. 4. The built-up combination was of ample strength. Each vertical reinforcing plank was so sawed that it was somewhat shorter than the horizontal one, so that it would not interfere with the bottom chords of the trusses.

At each point of attachment to a truss a top washer was used. This consisted simply of a piece of 1 1/2 in. by 1 1/4-in. strap iron with a hole drilled through it. It prevented the nut from interfering with the slot between the two channels forming the chord. The bottom washer was, as detailed in Fig. 4, a piece of strap iron with its ends bent up. Each bottom washer formed a rest for the ends of two adjacent running boards. With the boards and supporting arrangement in position the bolts were set up tightly clamping the combination firmly in position.

Illuminated Church Sign.—Base-filament glittering electric signs which prove so attractive for commercial institutions sometimes appear inappropriate for church use. A dignified and beautiful illuminated an-

nouncement is erected, however, in front of the First Baptist Church, Dayton, Ohio. The frame is of simple ecclesiastical design and incloses two art-glass panels in rich colors. In the smaller panel above, the name of the church is permanently fixed, while the larger glass furnishes space for lettering in announcements of the next Sunday's exercises. The lamps within the sign are controlled from a switch in the church vestry.

Illuminated Sign using Flaming-arc Lamps.—The accompanying Fig. 1 shows an arrangement of a flaming-arc illuminated sign, suggested by C. M. Axford, Chicago, in which a pair of lamps are used to illuminate the letters, and at the same time to light the sidewalk and store front where the sign is installed. The proposed construction is made clear by the sketch. The two flaming-arc lamps are connected

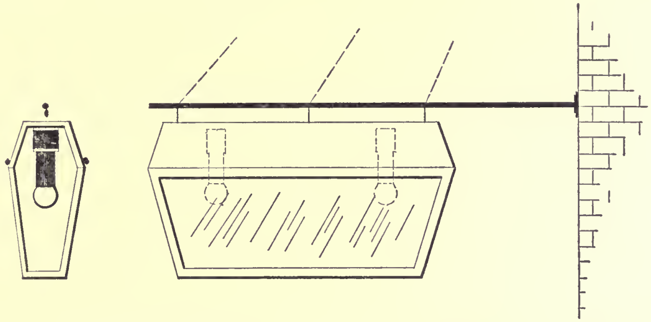


FIG. 1.—ILLUMINATED SIGN USING FLAMING-ARC LAMPS.

in series across 110 volts, and together consume about 1 kw. The signs should be black letters on a frosted background, or *vice versa*, and the sign surfaces should be inclined about 10 deg. to the vertical so as to be most effectively read along the street. Above the sign spaces are hinged doors, through which access can be had to the lamps for renewals. These doors should be provided with gutters discharging at the curb line. The street end of the box should be closed, or may be used for a small sign, while the end toward the building should be left open and preferably cut away as shown to allow light from the lamps to reach the windows and store front. For this purpose, the sign, which should be about 10 ft. in length, extending to the curb, should be mounted at least 4 ft. away from the building line, being suspended from a chain and bracket or other construction. Opal globes on the flaming-arc lamps will tend to improve diffusion of the light within the sign, and minimize "spotting" of the letters. The use of an illuminated sign of this kind is suggested in positions where it has been the custom to hang a pair of naked flaming-arc lamps in front of the store, depending on them to light the front and windows and the owner's sign. Under

such conditions, the extreme intensity of the lamps defeats the latter purpose, causing the passers-by rather to shield their eyes instinctively from the glare. The sign proposed would, on the other hand, show the proprietor's legend to advantage along the entire street, besides lighting his sidewalk and windows, all at a minimum electrical expenditure.

A "Kink" to Save Lamps on Series-multiple Circuits (By G. Zimmerman).—Where only direct current is available in downtown sections it is often necessary to use the series-multiple arrangement of low-voltage tungsten sign lamps. Such connections have given a great deal of dissatisfaction and annoyance by their rapid destruction of lamps following the burning out of one unit. To prevent trouble, the first lamp should be replaced immediately it is seen to be extinguished. In many large roof

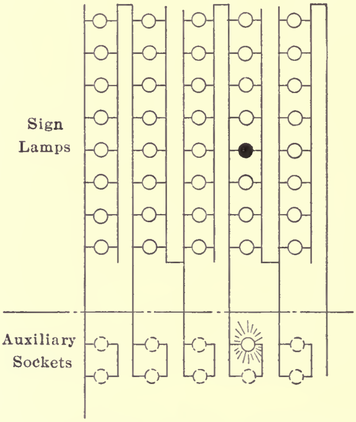


FIG. 1.—SAVING LAMPS ON MULTIPLE SERIES CIRCUITS.

signs and inaccessible displays it is out of the question to get ladders and go up on to the sign after dark to replace a single lamp. In such cases it has been found convenient to have the wires from each group of small lamps in multiple extended down to two or more sockets mounted in the roof-house or other easily accessible place. These sockets should be carefully labeled with the group to which they belong. Then as soon as a lamp on the sign is seen to be out, and its fellows making an effort to redivide the load among themselves, it is only necessary to insert a new lamp in one of the auxiliary sockets of the same circuit, again equalizing the current flow to its normal value. This will save the remaining lamps of the group as well as the operation of the whole display itself, and next day or once a week a man can go aloft to replace the accumulation of burned-out lamps. The remedy shown in Fig. 1 is inexpensive, only one wire being required from each group.

Electric-lighted Showcase for the Plate-glass Storeroom Door.—The plate-glass door of the average storeroom occupies valuable display

space, of which, however, little use is ordinarily made. Realizing this, an astute shoe merchant in a southern Ohio city had an electric-lighted showcase built, as shown in the Fig. 1, to be hung behind the glass door after business hours. Connection to the lamps inside is made by a flexible cord which can be plugged into an outlet at the side of the door. A couple of 60-watt tungsten lamps light the little box profusely, and the unique display draws more than its share of attention from the passing public.

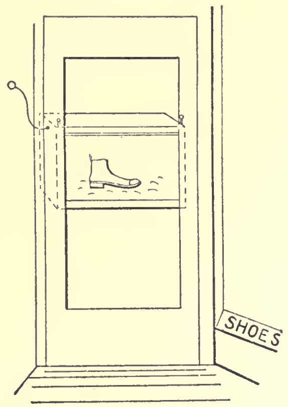


FIG. 1.—ELECTRICALLY-LIGHTED SHOWCASE.

Lighting a Chicago Store Window.—The drawing, Fig. 1 on page 112, shows the show-window illumination adopted for "The Hub," the well-known Chicago department store. The show windows are lighted by three rows of lamps, all of which are concealed from view. These are arranged to give cross lighting and thus to avoid any sharp contrasts.

Special Ceiling Surfaces for Indirect Lighting (By G. B. Collier).—An accomplishment of the moving-picture folk in improving the reflecting efficiency of their projection screens should offer a useful hint to those designing installations of indirect lighting. Having brought the intensity of the arc and the projecting machine up to its practical limit, the moving-picture men next attacked the problem of increasing the brilliancy of their pictures from the screen end, seeking a material of higher reflecting power than the ordinary sheeting commonly used. A picture thrown on canvas can, as is well known, be seen about equally well from the rear of the screen and from the lantern side, indicating at once an efficiency of only 50 per cent. in either direction. If part or all of these rays absorbed and passing on through the sheet could be returned on but the single useful side, the illumination of the picture would obviously be much increased. This result has recently been accomplished in the production of an improved screen, heralded on the billboards of the 5-cent theaters

as an "incandescent curtain" but really only a prepared surface of higher reflecting power than the ordinary white screen. The results are surprising, the pictures being far more brilliant and, as a result thereof, less subject to flicker.

The indirect-lighting art has now reached the same limitation. Employing reflectors and lamps of the highest efficiency, the over-all

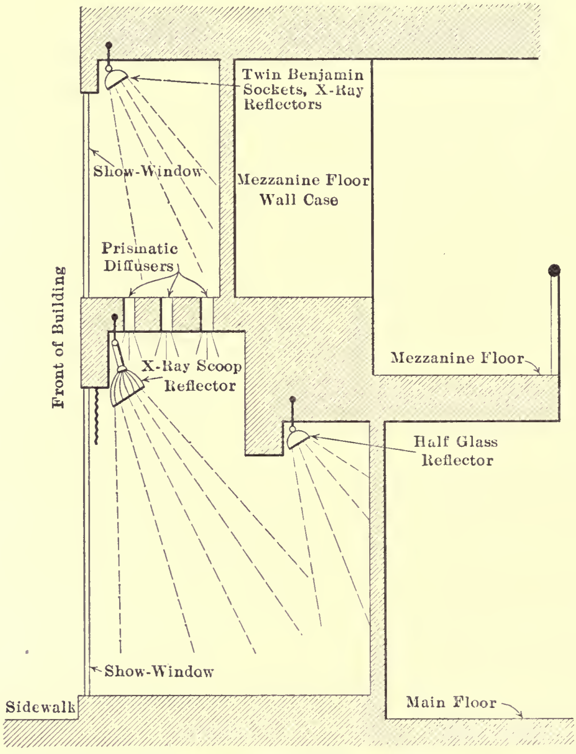


FIG. 1.—LIGHTING A CHICAGO STORE WINDOW.

results are yet tremendously reduced by the poor reflective coefficient of ceilings and walls. The character and tint of the coating applied to these surfaces where indirect illumination is to be used should be specified by the illuminating engineer as a part of the lighting system and not left to the judgment of architect, owner or painter, whose selection is made without knowledge of the duty of the ceiling as a reflector. There is no doubt that, following along the work of the moving-picture screen mentioned, special paints could be developed having albedoes or reflective coefficients much higher than those in use. With such paints and more of the light returning to the room and less entering the walls the present excessive wattage required with indirect lighting (about two to one

compared with direct illumination) might be substantially reduced and the physiological comforts of this system of lighting be more generally secured.

Danger of Broken Lamp near Inflammable Material (By. I. Clyde).—The accompanying illustration (Fig. 1) shows a diagram of a show window lighted by tantalum lamps, the breaking of one of which caused a fire resulting in loss both of life and property. Two shelves were joined together by a sloping board surmounted by a vertical board 9 in. high. All the shelves and boards were covered with cotton wool upon which were displayed celluloid combs, jewelry, etc. On the top of the vertical 9-in. board

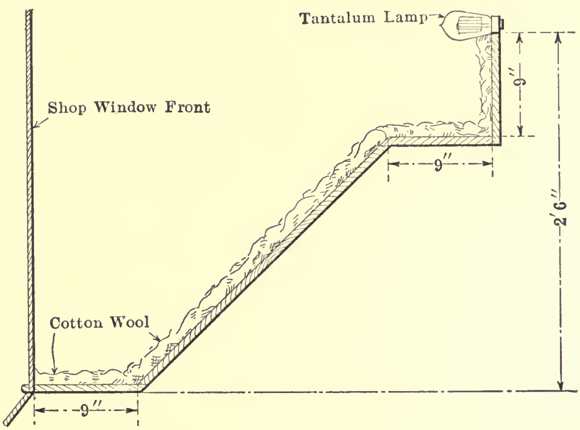


FIG. 1.—DANGER OF BROKEN LAMP NEAR INFLAMMABLE MATERIAL.

were clamped lamp holders arranged so that the lamps would be at right angles to the board and projecting over it into the window. Where the lamps projected the cotton wool was cut away in a circle. In all there were about twenty 16-c.p. tantalum lamps connected two in series across a 240-volt circuit by means of flexible wire. The lamps were spaced about 1.25 ft. between centers. While reaching into the window containing the lighted lamps a clerk is supposed to have broken one of the lamps and the hot filament ignited the cotton and celluloid and within a minute the whole window was ablaze. As to the actual cause there appears to have been some doubt, but experiments conducted subsequently showed that the supposition was tenable and that incandescent lamps installed under the conditions mentioned are a source of danger. In one experiment a lamp was suspended a distance of 3 in. over dried cotton wool and the bulb broken by a hammer. The broken filament instantly ignited the cotton wool and no fuses were blown. In another experiment a lamp was suspended 3 in. above cotton wool thinned out on which rested a celluloid telephone mouth-piece. On breaking the lamp both the

wool and the celluloid immediately caught fire. The incident shows the danger of bringing flimsy decorative material near lamps, especially in unventilated windows where the heat ordinarily would cause the material to dry thoroughly and make it more of a menace than one would suppose. The Underwriters have ruled against flexible cord in show windows, and if the installation has been made in accordance with the rules it is safe to say no fire would have resulted. Persons are too prone, however, to underestimate the amount of heat given off by an incandescent lamp.

An Electrical Advertising Novelty.—Near one of the Fifth Avenue stations of Chicago's elevated loop an ingenious projecting-lantern advertising sheet has been arranged to attract the attention of those

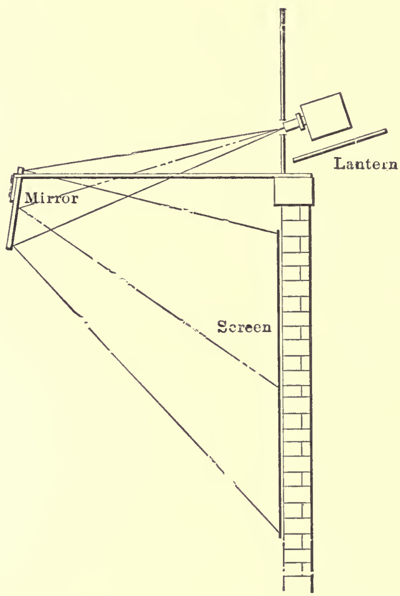


FIG. 1.—ELECTRICAL ADVERTISING NOVELTY.

waiting on the platform opposite. Through a protected opening in a window the lens of the lantern projects its rays against a mirror mounted several feet from the building and at such an angle as to reflect the image onto a screen on the wall below the window, where the rays come to a focus. This arrangement is made clear in the diagram, Fig. 1. Use of the reflecting mirror extending beyond the building avoids the necessity for a window opening equal to the size of the screen, requires less room in the building and does away with the bright spot shown by the lantern lens when the stereopticon is placed on the opposite side of the screen from the spectator, as would otherwise be necessary. Tendency to distortion caused by the angle at which the screen intercepts the pencil of

rays can be prevented by arranging the stereopticon slide with a swing back paralleling it to line of the building.

Influencing the Curio Seekers' Choice Electrically.—When the proprieter of a certain little curio shop in the city of Niagara Falls, N. Y., wishes to push the sale of any article or to emphasize the presence of any timely trinket in his showcase he does so by simply changing its position in the case. As is shown in Fig. 1, auxiliary illumination is

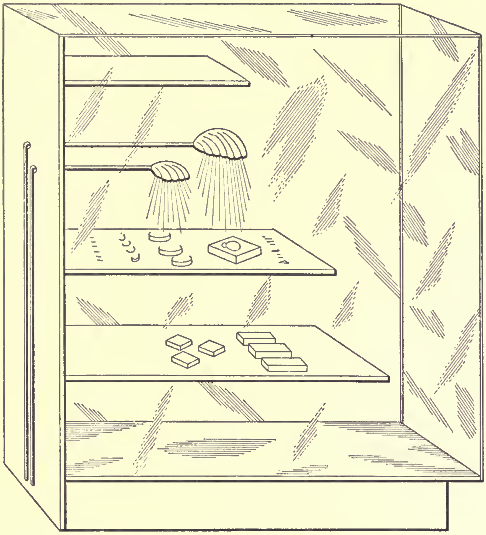


FIG. 1.—INFLUENCING CURIO SEEKER'S CHOICE ELECTRICALLY.

furnished by 10-watt tungsten lamps supported by extension arms and shades so as to throw the full intensity of their light upon the object beneath them. Catching the eye on account of its comparatively greater illumination, the tourist's attention is immediately directed to the very article which the shrewd shopkeeper is anxious to dispose of first. The low price of electrical energy in the Power City makes it practicable for shopkeepers to burn lamps all day as well as during the evening hours in places where illumination will increase the volume of the sales.

VII

LAMPS AND LIGHTING CIRCUITS, SIGNAL BELL CONNECTIONS, ETC.

Installation and Maintenance of Lamps, Special Installations, Adaptations to Special Circuits, Supervision and Control of Circuits

Lighting One Lamp on Four-lamp Fixtures With Three-wire System.—The method employed by the Kansas City Electric Light Company for supplying electricity to the four lamps on each street fixture so that one lamp may be operated all night and the advantages of a three-wire system when all of the lamps are lighted still be retained is interesting. At the 2200-volt distributing board in the central station are a double-pole oil switch and a single-pole oil switch connected as shown in Fig. 1.

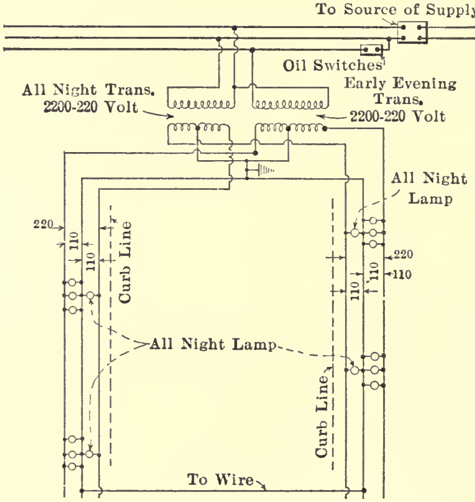


FIG. 1.—LIGHTING ONE LAMP ON FOUR-LAMP FIXTURES WITH THREE-WIRE SYSTEM.

Up to midnight both of these switches are closed; after that time the single-pole switch is opened, thereby leaving a single night lamp in service until sunrise.

Two single-phase transformers are used for each section and are connected as shown in the diagram. One transformer furnishes the energy for the lamps which are lighted till midnight (with the exception of the all-night lamp); the other transformer furnishes energy for the all-night

lamp only. A wire connects the middle of each secondary and is grounded in addition to being connected to one of the lines running along the top of each pole. By connecting the outer wires to the transformers as shown, 220 volts is maintained across them and the advantages of a three-wire system are thus obtained. The middle wires on each side of the street are tied together where practicable.

Lamp Protection.—In gymnasiums, hand-ball courts, indoor-tennis courts, etc., tungsten lamps should be protected against the chance impact of balls thrown by players by installing a wire screen or guard of some kind around the lighting units. Frequently the mistake has been made of attaching these guards to the lamp-holders themselves, with the result that when a ball struck the screen the jar and vibration transmitted to the whole fixture was sufficient to break the filaments. The

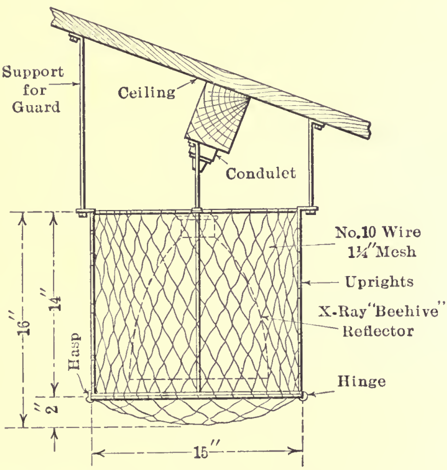


FIG. 1.—LAMP PROTECTION.

accompanying Fig. 1, shows the improved method of supporting the guard screen used in the case of a recently completed gymnasium in which the protector is separately mounted entirely clear of the lamp fixture and reflector. The bottom of the wire basket is hinged and held closed with a hasp, to give easy access for renewing lamps and cleaning globes and reflectors.

Rubber Band Prevents Lamp from Backing Out (By A. T. Vernon).—In a large industrial shop near Chicago, which is lighted by 500-watt tungsten lamps, trouble has been experienced from the vibration of the machinery and buildings, causing the lamps to "back out" and fall from their sockets. After several lamps had become unscrewed and smashed in this way, the experiment was tried of snapping an office rubber band over the threads on the base. When the lamp is screwed

up the friction of this rubber causes the brass cap to be gripped firmly, thereby preventing any movement that might allow the lamp to back out. After the rubber band has been in place several weeks it usually becomes so gummed as to hold the base all the tighter.

Lamp-cord Adjusters (By E. E. George).—The following device has been found very useful for droplights, as it not only takes up the slack in the cord, but permits the placing of the lamp at almost any point of the room. On the two end walls of the room, near the side walls, about 7 ft. or 8 ft. from the floor, fasten four hooks. Through these hooks run an endless cord (chalk line is very serviceable). This cord must be sufficiently slack to enable it on one side to be looped around the slack of the lamp cord and on the other side to be doubled through a Fahnestock connector fastened by some means to the lamp socket. The loop through the connector can be shortened or lengthened to lower or raise the light. It usually takes some experimenting to determine the lengths of cord, and also of lamp cord, that will give best results; but it is possible so to adjust the two that the lamp can be moved almost in a flare all over the room. The lamp will stay anywhere it is placed.

Holder for Removing Street-series Receptacles.—For removing and replacing street series receptacles the line department of the Omaha

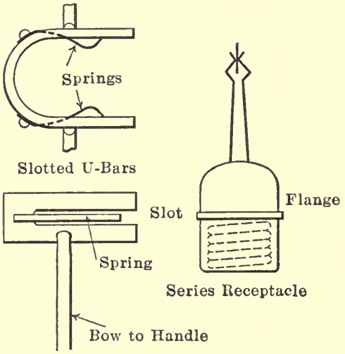


FIG. 1.—HOLDER FOR REMOVING STREET-SERIES RECEPTACLES.

Electric Light & Power Company finds that the home-made U-bar device, Fig. 1, has many advantages over the usual pull-rope extractor. The holder is formed of two U-bars with a slot between them wide enough to span the flange on the porcelain receptacle. Working in the slot are a pair of light springs which grip the socket just firmly enough to prevent it from falling out of the holder while being lowered. The slot itself holds the flange firmly against any vertical movement. A long wooden handle is attached to the holder through a spreader bow which clears the lamp.

Cradle Clamp for Hanging Arc Lamps.—The cradle used for hanging arc lamps which is shown in the sketch, Fig. 1, has proved of great value in installing the new 10-amp. flame lamps at Omaha, Neb. These lamps, as is generally known, contain an annular row of loose chemical blocks inside the casing and above the globe. The blocks are laid insecurely in place, and if the lamp is tilted much while being hoisted into place, one or more blocks may become dislodged and fall into the globe, necessitating lowering, adjusting and hoisting the lamp all over again. If the lamp be lifted by an ordinary rope loop, it cannot, of course,

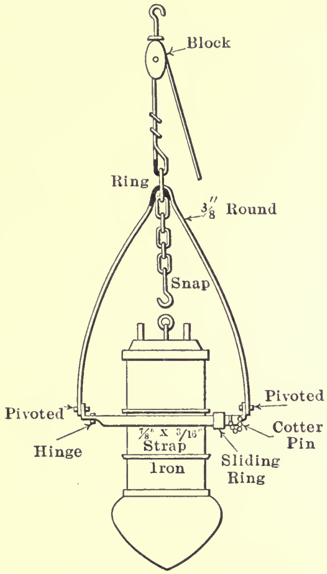


FIG. 1.—CRADLE CLAMP FOR HANGING ARC LAMPS.

be hoisted vertically, and even if hoisted by the hanger ring it will invariably be tilted while being pushed over and transferred to the permanent suspension hook.

The rig illustrated was devised by F. Dickinson, and consists of a strap-iron ring hinged so as to open, but held shut to clamp the lamp case by a slip-ring with a protective collar pin. The suspension bale is pivoted to the hanger, as labeled in the illustration. The snap in the center is of help when first placing the lamp in the cradle. The lamp can be hung on the hook, which holds it free of the man's hands while the clamp ring is being closed and made fast. The whole rig is then hoisted to the proper height, turned 90 deg. from the plane of the paper as shown, and while held vertically with care, its weight supported by the cradle, is pushed over under its permanent hanger and connected. Use of this

pivoted device has enabled the work of hanging the lamps to proceed much faster and has saved time lost in lowering and replacing lamps.

Operation of Series Alternating-current Street Arc Lamps (By J. C. Lawer).—All municipal arc-lighting contracts should specify the type and ampere rating of the arc lamp to be supplied. In addition, the average wattage consumption, number of hours burned, allowable outage, etc., should be clearly specified, and the company in pursuance of its contract should make a periodic statement showing the operation of its arcs in detail.

Two municipalities demand sworn monthly reports (which will be described later), and the contract specifies that series 7.5-amp., 60-cycle alternating-current arcs are to be supplied and that the average consumption per lamp must not be less than 490 watts. The lamps must burn from dusk until dawn, which is considered as 4000 hours in the aggregate per annum. These contracts are defective in many ways in that some agreements had to be made afterward in regard to line loss, transformer efficiency, method of inspection and allowable outage; however, they present the possibilities for a new contract which should be satisfactory and free from any future misunderstandings.

This form of contract affects the operating department and it must be prepared quickly to test the lamps for a predetermined wattage and maintain its reports in a systematic manner. The following methods and appliances have been adopted by an operating company.

A Convenient Test Board.—Fig. 1 is a wiring diagram for an arc-lamp test board. The right end is arranged for connecting two alternating-current series lamps and the left side for three alternating-current multiple lamps. The indicating wattmeter, ammeter and voltmeter at the center of the board may be used for testing one lamp at a time of either type by properly operating the switches. The board is practically fool-proof, and it is impossible to connect the two types of lamps to the instruments at the same time so as to do any damage. The double-pole double-throw switch directly below the instruments controls the potential to the wattmeter and voltmeter and must be thrown toward the type of lamp under test. On the multiple side the supply current is preferably controlled by a double-pole, single-throw switch protected by fuses. The three test loops for the multiple lamps are each controlled by a single-pole, double-throw switch. Any one of these switches thrown to the left (away from the instruments) permits the lamp on that loop to burn independently of the instruments. When the switches are thrown to the right the lamp is connected to the loop controlled on the instruments unless the series lamps are already on the instruments, in which case the multiple lamp would be extinguished.

The series circuit is supplied by means of a six-lamp constant-current

transformer through a bank of four lamps for load. There are two series test loops controlled by two single-pole, single-throw short-circuiting switches. The potential for the voltmeter and wattmeter is controlled by a double-pole, double-throw switch which must be thrown toward the series lamp under test. The series lamps may be thrown off or on the indicating instruments by means of two absolute cut-out hood switches, which form the principal part of the "fool-proof" device. These two hood switches are placed end to end so as to be operated by one handle or lever; the lower hood switch, as shown, has the short-circuiting bar

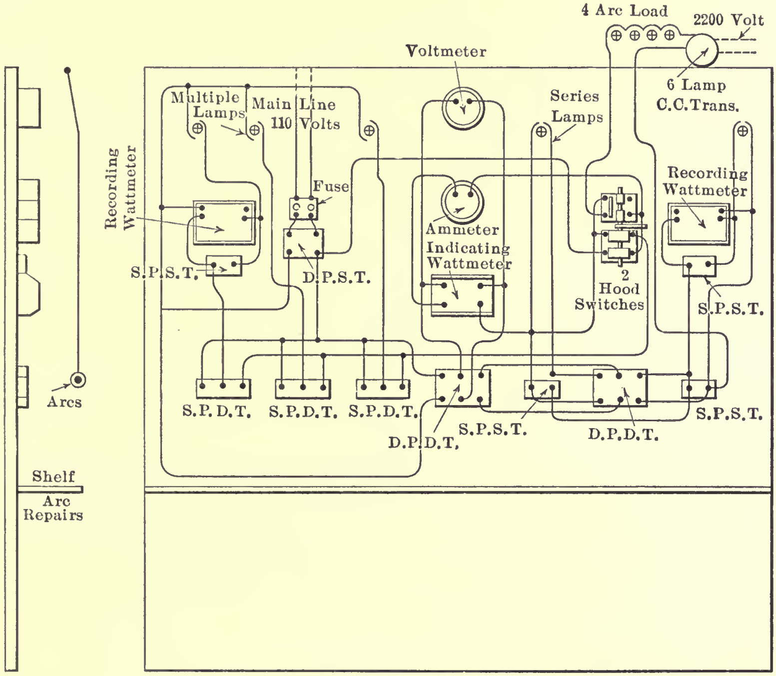


FIG. 1.—CONVENIENT ARC-LAMP TEST BOARD.

removed and operates as a two-pole, single-throw switch. These switches are so connected that with the lever thrown to the right (away from the instruments) the series lamps are short-circuited from the instruments and the lower switch completes the multiple circuit through the instruments. When the lever is turned to the left the series circuit by means of the top hood switch is completed through the instruments and the multiple circuit is broken by means of the lower hood switch. One test circuit of the multiple lamps and one test circuit of the series lamps are provided with a recording wattmeter and short-circuiting switch. The latter meter should be adjusted for 72 volts, and both for low power-factors.

The test circuits should be suspended in front of the board at a convenient height.

Methods of Testing Alternating-current Series Arc Lamps.—It is desirable to have all lamps on the circuits consume as near a predetermined rate as possible. The lamp consumption not only depends upon the internal adjustment of the lamp, but there are several things beyond our control which must be allowed for.

Weather affects the consumption on a circuit of series lamps as much as 10 per cent. This is principally due to the variation of temperature in the shunt coil. When the shunt coil is at a low temperature and consequently low resistance it will pull a shorter arc, thereby reducing the voltage across the arc with a resultant lower wattage. The series coil is not perceptibly affected by the change in temperature, as the constant-current transformer maintains it at a constant strength. The line loss is less in cold weather, and where this loss is taken at a constant percentage the lamps must be operated at a slight percentage above the demanded rating.

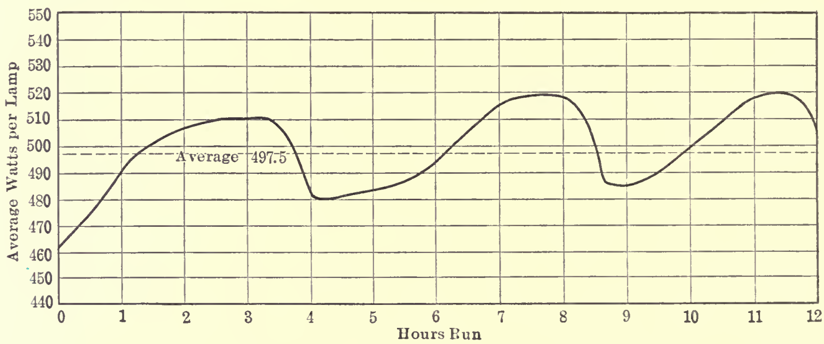


FIG. 2.—VARIATION IN WATT CONSUMPTION ON SERIES ARC LAMPS.

The length of carbon also affects the consumption. The longer the upper carbon the heavier, and it tends to produce a shorter arc. A circuit of arcs newly trimmed will show a decided decrease in consumption partly caused by the greater weight, but principally due to the low resistance of the carbon tips, and even while the arc may be excessively long the consumption will remain low. It requires approximately forty minutes' burning before the carbons reach a normal condition.

Fig. 2 shows the variation in the average consumption in watts on a circuit of series arcs taken for a continual run of twelve hours with practically constant outside temperature. It will be noted that the minimum occurs when the lamps are first turned on and are cold. The consumption increases over three hours as the lamps become warmer and as the arc becomes longer due to the carbon tips being consumed. Between

three and four hours after the arcs are started the "feeding point" is reached. Some lamps will extinguish themselves for an instant and start at a low consumption as the feeding takes place. Other lamps will feed a perceptible amount every few minutes, probably never extinguishing themselves, and will operate at a fairly constant rate. It is the feeding point that causes the watts to drop, but it will be noted that this drop is not as low as at the original starting point. The continual heating and shortening of the carbons cause each successive feeding point to reach a higher consumption than the preceding one. For this reason an eight-hour test will show a lower average consumption than a twelve-hour test. The high consumption caused by the long-hour burning in winter may be offset by the colder weather.

As eight or twelve hours is too long for a practical test in the shop on individual lamps, the following short method may be adopted for the 7.5-amp. and 6.6-amp. lamps:

The lamp should be trimmed with used carbons of about half length and allowed to burn on the test rack for at least forty minutes. It should then be switched on the indicating instruments and the short-circuiting switch thrown in for an instant until the carbons have dropped together and the magnets fallen. The switch is then opened and the ammeter is noted to see if it indicates the proper amperage. If the lamp under test is of the 7.5-amp. type the indicating wattmeter should show 470 watts. This may be called the starting wattage. Then the carbon is held firmly against its guide and at the same time the series magnet and mechanism pushed down until the clutch can take a new hold of the carbon at as low a point as possible. The mechanism is then released, and when the clutch has taken hold the grasp on the carbon is released. The indicating wattmeter should within a minute read 510 watts to 515 watts. This is the "feeding point" and the lamp should soon drop its carbons and wattage. This test requires some practice and several trials, but a lamp so adjusted will average from 495 watts to 505 watts on long-hour burning.

Nearly all new lamps are fitted with a clutch stop which prevents the globe cap from melting when the lamp is newly trimmed and the arc is excessively long; however, care must be taken to see that the bar of the stop is placed sufficiently high to prevent the clutch from striking it before the feeding point is reached. The bar should not touch the clutch while the lamp is under normal running condition.

A worn clutch will permit the carbons to slide together, and if a new clutch is placed on the lamp care must be taken that it shall have as much play and grasp the carbon like the old one, or it may be necessary to readjust the entire lamp.

Method of Inspection.—Requiring an exceedingly careful supervision

of its street arc lamps, one company placed night inspectors on regular routes to see that all lamps were kept burning. These inspectors carried regular night watchman's clocks and were compelled to visit certain

SUMMARY OF MONTHLY REPORTS

Month	Lamps burned Hours	Lamps burned Minutes	Net watt-hours consumed	Number of lamps	Apparent lamp-hours	Hours outage	Net lamp hours	Per cent. outage	Watts per lamp
January....	406	27	53,833,860	268	108,579	295	108,284	0.0027	497.1
February...	345	11	47,027,000	270	92,871	352	92,519	0.0038	503.3
March......	344	03	46,895,510	274	93,923	473	93,450	0.0050	501.5
April.......	293	00	40,401,930	275	80,431	301	80,130	0.0037	504.2
May.......	269	46	36,821,880	276	74,456	207	74,249	0.0028	494.5
June.......	239	36	32,999,100	276	66,130	1,052[1]	65,078	0.0159	507.1
July........	270	50	37,798,890	276	74,750	161	74,589	0.0021	506.8
August.....	309	15	41,324,478	276	85,353	446	84,907	0.0052	486.7
September..	332	13	46,666,800	276	91,692	484	91,208	0.0053	511.6
October	375	09	50,983,740	276	103,541	613	102,928	0.0059	495.3
November. .	395	58	53,743,380	276	109,287	682	108,605	0.0062	494.9
December...	424	31	58,056,840	276	117,167	2,281[1]	114,886	0.0195	505.3
	4,005	59	546,527,408	....	1,098,180	7,347	1,090,833	0.0067	501.0

[1] High due to lightning and wind storm.

remote stations in order to get their registering keys. They made two rounds of their circuits every night and turned in their clocks to a supervisor every morning with their reports. From these reports the lamp-hour outages are obtained. Following is an arc inspector's report:

Time found	Location	Cause	Lamp hour outage
8 : 10	5th and A St.	Carbon stuck	1 hr. 10 min.
8 : 30	9th and B St.	Broken inner globe	1 hr. 30 min.
9 : 00	5th and A St.	Carbon stuck changing lamps	40 min.
	Total lamp-hour outage......................		3 hrs. 20 min.

A lamp is considered as "out" from the time the circuit was turned on or off from the time of the last inspection. This record enables the supervisor to "spot" a lamp which continually gives trouble; also, the greater number of actual outages found prevents the company from having to operate its burning lamps so far above normal in order to maintain the required average watt consumption. Experience has shown that a newly trimmed circuit will show abnormal outages.

Following is a form of monthly arc-lamp report furnished the city:

1. Total number of hours burned..............................	406 hrs. 27 min.
2. 267 lamps in service of month, lamp-hours....................	108,522
3. One lamp installed 27th, lamp-hours.........................	57
4. Total apparent lamp-hours................................	108,579
5. Total lamp-hour outages..................................	295
6. Net lamp-hours...	108,284
7. Watt-hours, primary......................................	61,878,000
8. Watt-hours at lamps (87 per cent.)...........................	53,833,860
9. Average watts per lamp...................................	497.1

The first line indicates the total number of hours the lamps were turned on during the month. The second the number of lamps in service the first of the month multiplied by the hours burned, giving the apparent lamp-hours. The third indicates the lamp-hours of lamps that were installed during the month. The fourth is the sum of the second and third, giving the total apparent lamp-hours for the month. The fifth is the total lamp-hour outages taken from the night inspectors' reports. The sixth is the net lamp-hours burned. As to the seventh line, the recording watt-hour meters were necessarily placed on the primary of the constant-current arc transformer and were agreed to have an efficiency of 94 per cent. The line was entirely of No. 6 copper and the loss was originally taken according to the C^2R losses. This came so near a constant percentage that the combined efficiency of the line and transformers was fully agreed on as 87 per cent. Thus the eighth line shows 87 per cent. of the seventh line. The ninth line is the eighth divided by the sixth and gives the average watts at the terminals of the lamps.

Owing to sudden weather changes it was found advisable for the supervisor to keep his report practically up to date during the month in order not to run short or be far above the required watts at the end of the month. The watts could be changed very readily by making a slight adjustment of the weights on the constant-current transformer, which would cause scarcely any perceptible variation of the ammeter.

Overcoming Overload on Series Arc-lamp Circuits (By Charles E. High).—It sometimes happens in planning the installation of a series

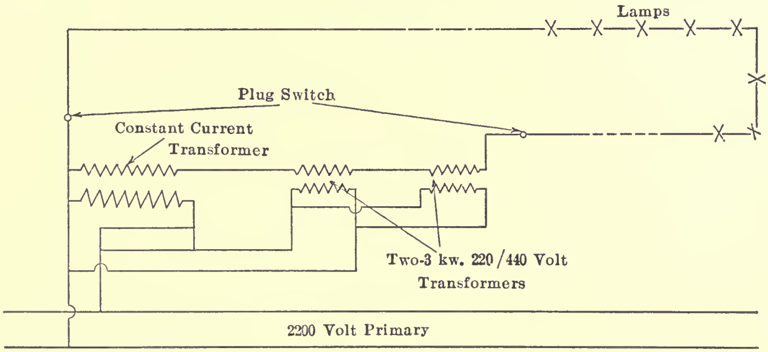


FIG. 1.—OVERCOMING OVERLOAD ON SERIES ARC-LAMP CIRCUITS.

arc-lighting system that sufficient allowance has not been made for the future growth of the plant, with the ultimate result that the constant-current transformer which has been provided becomes overloaded. Many times this overload is not sufficiently large to justify the expense of securing another constant-current unit. This was the case with our plant. A twenty-five-lamp transformer had been installed with the

plant and first connected for 60 per cent. load. This was later changed to 80 per cent. load, then to full load, and with the addition of still more lamps the intensity of the light began to diminish. To overcome this difficulty the scheme of Fig. 1 was devised. The primaries of two 3-kw., 2200/440-volts stationary-element potential transfomers were connected in multiple with the primary of the constant current unit, and the secondaries of all three transformers were then placed in series and connected directly to the lamp circuit. This plan allowed the operation of thirty-seven lamps on a twenty-five-lamp circuit and gave satisfaction in every way. The lamps returned to their normal brilliancy and no transformer was heated excessively. The constant-current transformer, operating on the margin, as it were, and maintaining the current at 6.6 amp., was assisted by the stationary element units, which boosted the voltage on the circuit and helped supply energy to the extra lamps. Care must be exercised in making the connections that proper polarities be maintained in the transformers.

Lamp Operation Due to Accidental Grounds.—Among the troubles recently reported to an Eastern central-station company was the complaint of one customer that he could not turn out part of his lamps.

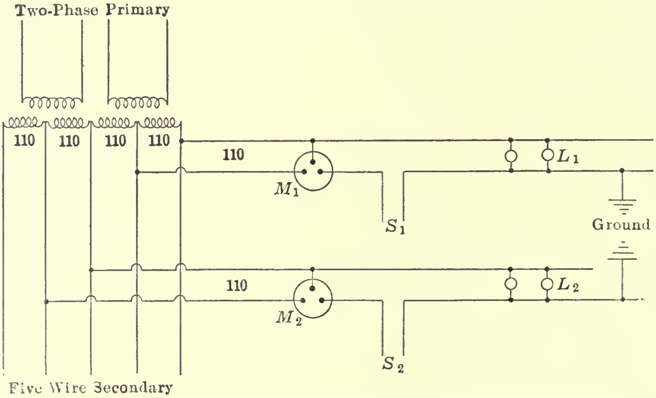


FIG. 1.—LAMP OPERATION DUE TO ACCIDENTAL GROUNDS.

When his snap switch was turned "off" the lamp candle-power was simply reduced, the filament continuing to glow dimly. While this case was being investigated another customer came in with a similar complaint concerning his own installation, which was about 150 ft. distant from the first. Inspection showed that although both customers' snap switches might be open, the lamps would burn at low voltage. Furthermore, it was found that this energy consumption was not being recorded on either meter. With one switch closed, its own lamps would burn at normal voltage and candle-power; meanwhile the second

set of lamps received about 50 volts and could not be turned off by means of their own switch.

After a search the accidental ground of the first installation was located in a fixture which had been hung without an insulating joint. In the second case the ground was caused by abraded insulation where a wire passed through an iron post. As shown on page 126, these two grounds completed the circuit between the pair of 220-volt mains, so that while both single-pole switches were open the pairs of lamps were burning in series-multiple through the ground resistance. It so happened, too, that the grounded side in each case passed through the series coils of the meter, so that no registration was made of the current continuously in the fugitive circuit.

Locating Faults on Series Lighting Circuits (By Verne James).—The usual method of testing dead series circuits for grounds is to disconnect the circuit from all station apparatus and then to connect one terminal of a magneto test set to the circuit and the other to ground. If the bell rings vigorously when the crank is turned, the circuit is grounded. If it does not, the circuit is clear. If the circuit is very long or in cable for a considerable portion of its length, the bell may ring even if the circuit be

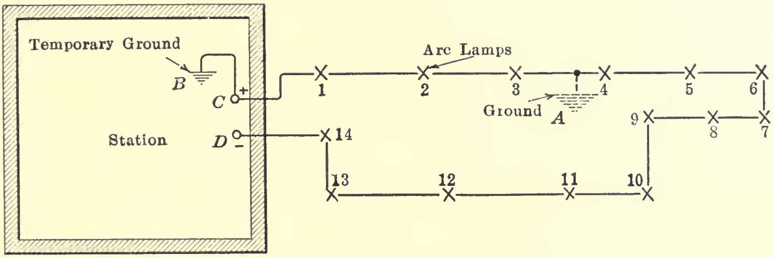


FIG. 1.—LOCATING A GROUND ON A DEAD CIRCUIT.

clear of grounds. The method of locating a ground on a dead arc circuit is illustrated in Fig. 1. Disconnect all station apparatus and temporarily ground one side of the circuit as at *B*. Proceed out along the line and connect some testing instrument (a magneto test set is most frequently used) in series with the circuit at some point. If when the crank is turned the magneto bell rings, indicating a closed circuit, the tester is between the station ground and the ground on the circuit. If the magneto "rings open," the tester is between the circuit ground and the ungrounded station end of the circuit. If the test set is inserted at lamps 1, 2 or 3, the magneto should ring "closed," while if inserted at any of the other lamps it should ring "open."

In locating either a ground or a break on a series circuit, unless the tester has an idea as to the location of the trouble, he should proceed to

the middle point of the circuit and there make his first test. This first test will indicate on which side of the middle point the trouble is. He should then proceed to the middle point of the half of the circuit that shows trouble and there make another test. This will localize the trouble to one-quarter of the circuit. This "halving" of the sections of the circuit should be continued until the trouble is finally found.

A ground on a series circuit can sometimes be located with the current from the arc generator or rectifier by placing a temporary ground on the circuit at the station. For example, if a temporary ground is connected to terminal *B* and the device that supplies the operating current to the circuit is connected to terminals *C* and *D* and normal operating current thrown out on the circuit, the lamps 1, 2 and 3 will not burn, indicating that the ground is between lamps 3 and 4. This method is attended by some fire risk, hence should be used with caution.

A method of locating a ground on a series circuit with lamp bank is suggested in Fig. 2. A bank of 110-volt incandescent lamps, each of the

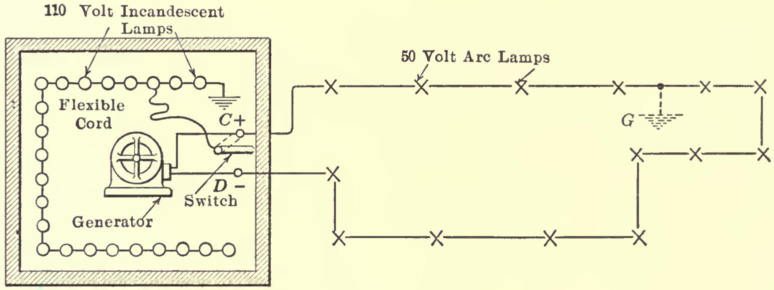


FIG. 2.—LOCATING GROUND ON A SERIES CIRCUIT.

same candle-power, is connected in series as indicated and one end of the bank is permanently grounded. There should be a sufficient number of lamps in the bank so that the sum of the voltages of all of the lamps is at least equal to the voltage impressed on the series circuit by the arc generator or the regulator.

In locating a ground the flexible cord which is connected to the center point of the double-throw switch is successively placed on different points on the conductor that connects the incandescent lamps in series, the switch being thrown to one or the other of the circuit terminals *C* or *D*. Move the flexible cord along until the incandescent lamps in the bank between the point of connection of the cord and the permanent ground burn at about full brilliancy. When this condition obtains the voltage impressed across the lamps that are burning at full brilliance is approximately equal to the voltage impressed on the portion of the arc circuit (to which the switch connects) between the station and the ground.

The voltage required across each lamp of the outside circuit being known, the number of lamps between the station and the ground can be readily computed, and thereby the ground is located.

For example, consider Fig. 2. There is a ground on the circuit at G. It is found that two of the incandescent lamps of the bank burn at full brilliancy between the flexible cord connector and the lamp-bank ground. Since 110-volt lamps are used in the bank, the voltage across these two is 220. This means that the voltage on the arc circuit between points C and G is about 220. Since the arc lamps each require about 50 volts, there must be $220 \div 50 = 4.4$, or in round numbers 4, arc lamps between C and the ground G. After making a test with the switch point on C, it should be thrown over to D and a check test made from the other end of the circuit. The method is the same in each case.

To locate a break in a series circuit, ground one end of the circuit at the station, as in Fig. 1. Then make tests at different points out on the circuit with the magneto connected in between line and ground. So long as the magneto bell indicates a closed circuit, the open is on the line side of the tester. When the magneto indicates an open circuit the open is toward the station from the tester.

Lamp Signals for Hotel Maids.—To locate housemaids at the Hotel Radisson, Minneapolis, the following lamp signal system is used by the office staff. In every corridor at the side of the door of each guest room is a 2-c.p. incandescent lamp, and on the wall below is a flush-plate contact jack into which on entering the room the maid inserts a plug carried on her key ring. With the plug in place the little lamp over the door is lighted, indicating from any point in the corridor in which room the maid is working. The circuits from these door lamps are in turn grouped in a signal board in the hotel office, so that the lighting of each room lamp is indicated by its corresponding lamp on the annunciator board. If a certain room is to be made ready on short notice, the maid on that floor can be reached by noting in what room her lamp is burning and then calling the corresponding number over the telephone.

Lamp Signal System for a Restaurant.—In the new café of the Boody Hotel, Toledo, a row of fifteen frosted ball lamps is mounted over the entrance doorway. Each lamp bears a number corresponding to those of the waiters on duty. After delivering his order to the chef, the waiter is instructed to return at once to his dining-room station. Then as soon as the food is prepared the kitchen serving man closes the corresponding switch, lighting the numbered lamp in the dining room and calling the waiter. This system keeps the waiters in the dining room, where they can give attention to other guests, and yet causes no delays in prompt service of orders when ready. The position of the lamps enables the waiters to watch for the entrance of guests while awaiting their signals.

In the brightly lighted interior the operation of the call lamps is not obtrusive, although the numbers can be read from any part of the room.

Lamp Signal System for Hospital.—An electric-lamp signaling system without solenoids or other complications is used in St. John's Hospital, St. Louis, for calling nurses and attendants to patients' rooms. In view of the fact that the ordinary bedside cord push-button may possibly injure the patient by shock or by his rolling upon it, a soft linen pull-cord with a light tassel has been substituted. A slight jerk on this cord trips out a contact switch in the wall fixture, completing an 11-volt circuit which lights a miniature lamp at the room door, another in the

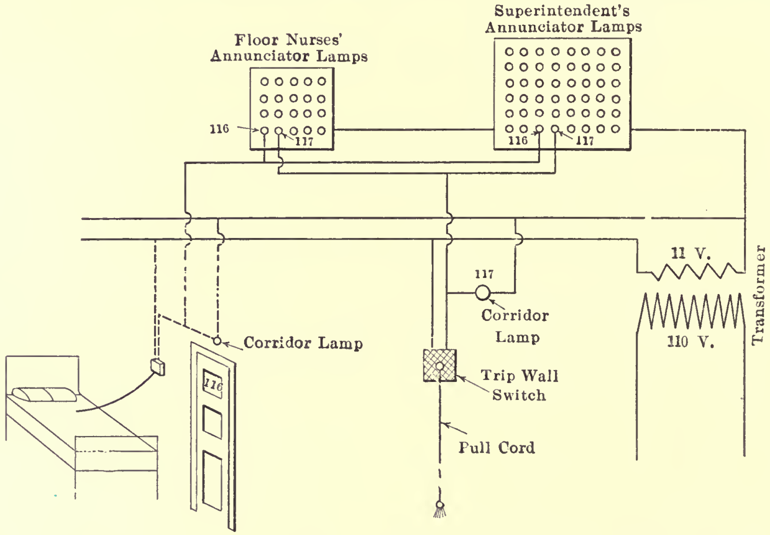


FIG. 1.—LAMP SIGNALS FOR A HOSPITAL.

annunciator in the nurses' quarters and a third in the superintendent's office. The lamp by the door is designed to attract the nurses' attention is she should be passing in the corridor at the time. Reproduction of all signals in the superintendent's office affords official supervision of the promptness with which calls are answered. With the system installed at St. John's the nurse cannot "clear out" a call without going to the room where it originated and resetting the switch. This is done by pressing a handle back into place. This feature assures that the signal will continue to be shown until the call has been answered. The soft pull cord is more easily handled by a sick man than a spring push-button, and since all electric wires end at the wall plate he cannot be injured by accidental shock or by rolling on to the hard pear-shaped button. A low-voltage sign transformer furnishes the 11-volt energy for the signal system, which serves 240 private patients' rooms besides the

general wards. For the latter individual lamps have been provided at the patient's beds, so that the source of any call can be followed back promptly. Some of the larger wards are also furnished with annunciator groups. The rooms where delirious patients are confined have emergency call buttons near the doors for use of the nurses. These light blue lamps at the doors and in the various signal centers, indicating that help is urgently needed and summoning anyone who may be near. C. J. Sutter devised this system which is shown in Fig. 1.

Lighting Fixtures in a Bank.—The accompanying Fig. 1 shows the type of lighting fixture used in the banking space on the second floor of

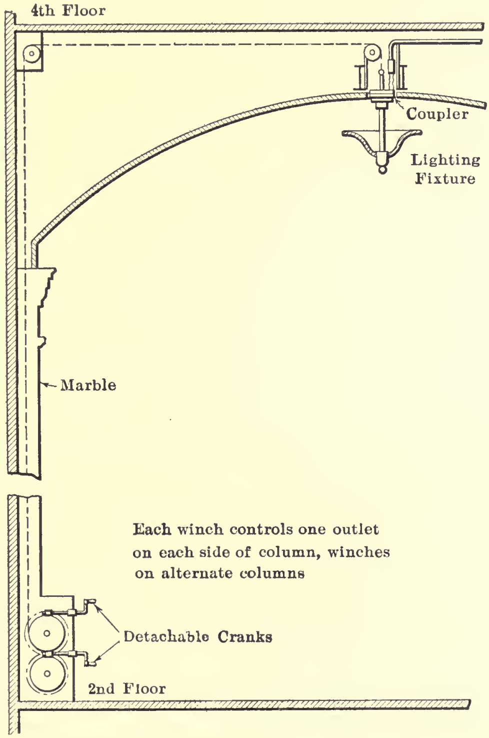


FIG. 1.—LIGHTING FIXTURES IN A BANK.

the Continental & Commercial Bank Building, Chicago. Supported from the crests of all of the arches in each bay are semi-indirect lighting fixtures, containing eleven 60-watt tungsten lamps, arranged so that they can be lowered for cleaning and relamping. Each of these fixtures is supported by two bronze cables which run over pulleys concealed in the ceiling and terminate in a hand-operated winch. When the fixtures are lowered the electrical connection is automatically broken at the ceiling so that

the lamp sockets can never be energized when the fixture is being cleaned or relamped.

The disconnect device consists of two plungers which form the terminals of the lamp fixture. When the fixture is in position to be lighted the plungers are pressed by helical springs against segments which connect with the terminals of the service lines. An interlocking device is installed which prevents arcing at the disconnecting point by opening a service switch when the fixture is lowered.

It may be interesting to note that these lamps are all fed from the fourth-floor cut-out cabinets, on account of the height of the ceiling, and are controlled by momentary-contact pilot switches which operate remote-control switches located in the cut-out cabinets on the fourth floor. The pilot switches are installed in gangs on columns at four corners of the banking space, so that all of the bank ceiling lamps can be controlled from any one of these positions.

Control of House Lamps from Central Switch (By S. Fisher).—It is easy to arrange the wiring of a house so that a given number of downstairs emergency lamps can be switched on from an upstairs apartment in case of a burglar "scare." While the cost is a little greater than for

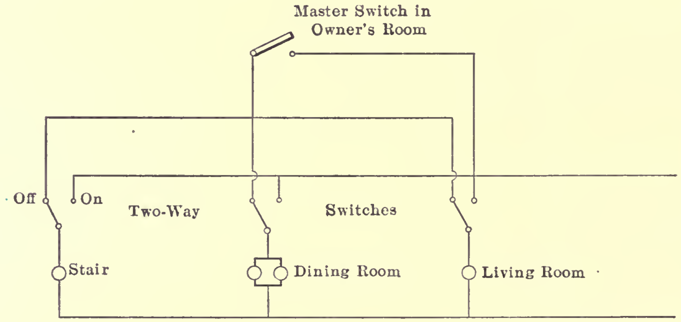


FIG. 1.—CONTROL OF HOUSE LAMPS FROM CENTRAL SWITCH.

the ordinary way, this expense is negligible compared to the satisfaction felt by the owner who, hearing a noise, can flood the downstairs rooms with light. The two-way scheme of Fig. 1 applies where wall switches are used. One position of the switch is connected up as the live stud, and the other contact is tied to the master switch in the owner's room. Closing this switch lights all the other lamps, regardless of the position of their switches, and these lamps cannot be extinguished except at the point where they were turned on. If desirable several master switches can be employed on various floors, any of which will turn on all the lamps.

Mercury-vapor-incandescent Lamp Cabinet for Photographic Work.—After combating the prejudices which subjects display against having

their photographs taken under the greenish glare of the mercury vapor lamp, M. J. Steffens, a Chicago photographer whose work is confined to portraiture of the best class, has constructed a lamp cabinet for use in his studio, in which the red rays from carbon-filament "linolite" lamps are combined with the mercury-vapor light. As a result of this combination the illumination afforded is nearly natural in color, and effects are said to be obtained on the photographic plate that have been impossible with other qualities of either artificial or natural light. The "snappiness" of outline of the mercury lamp is retained, while the red rays render the representation of lips and skin tones more nearly correct. Of course, the electrical efficiency of the illumination is reduced from the high figure attained by the mercury-vapor tubes alone, as the consumption of the complementary carbon lamps exceeds that of the tubes themselves.

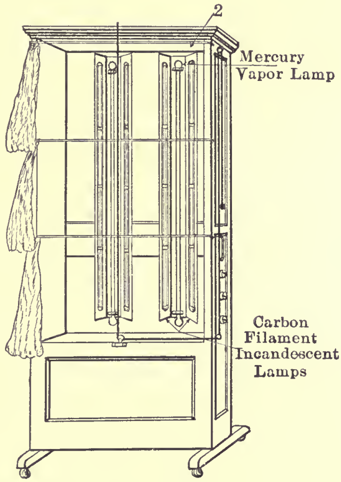


FIG. 1.—PHOTOGRAPHER'S LIGHT CABINET.

The cabinet (Fig. 1) constructed for use in Mr. Steffens' studio, consists of an oak frame, 4 ft. wide and 7 ft. high, in which are mounted two Copper-Hewitt self-starting mercury-vapor lamps with tubes vertical. On the white-enamel reflectors of these lamps and paralleling the tubes on each side are mounted polished reflecting troughs, each containing four 16-c.p. carbon-filament "linolite" lamps. Experiments have been made with clear-globe and red-dipped lamps, and a combination of the two is at present used in the Steffens studio. Each of one the Cooper-Hewitt lamps consumes 385 watts at 110 volts, while the eight 16-c.p. carbon lamps required to correct the color characteristic take 440 watts. This obviously reduces the high electrical efficiency of the mercury-vapor installation, but it works important results in the satisfaction of patrons

unaccustomed to the mercury-vapor light, and who object to its use. The cabinet containing the lamps is equipped with a tracing cloth shade for securing diffused illumination, and is also fitted with three sets of sliding curtains, so that the light cast on the subject can be controlled perfectly in amount or direction. The lamps are energized through a flexible cable, with a plug connection, so that the cabinet can be rolled to any part of the studio.

At a national convention of photographers in Milwaukee during 1910, Mr. Steffens was awarded first prize for having produced the "most useful and valuable" protrait device during the year.

Automatic Extension of Connection Bell (By W. H. Johnson).—On one occasion the writer made the following use of a two-way switch when called in to install a telephone extension bell in a small factory. It was desired to have the extension bell ring out in the shop when no one was in the office to answer it, but some means was also required for cutting off the bell when the office was occupied. The office was on the ground floor in a corner so dark that artificial light was needed all

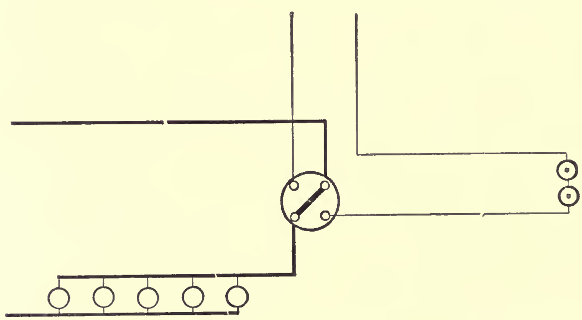


FIG. 1.—AUTOMATIC CUT-OUT FOR EXTENSION BELL.

day. As it seemed safe to assume that the bookkeeper or his assistant would turn on the lamps while they were in the office and switch them out of circuit when they left, both the lighting circuit and the bell circuit were connected through the two-way switch Fig. 1, with the result that when the lamps were lighted the bell was out of circuit and when the lights were extinguished the bell was connected. Of course, the lamp and bell circuits are entirely independent and insulated from each other. The arrangement has proved an entire success so far as the automatic disconnection of the bell is concerned.

Economical Street-lighting Wiring Arrangement.—The Worcester (Mass.) Electric Light Company installed a number of trial circuits of 4-amp., 75-watt tungsten series incandescent lamps early in 1912 in connection with the illumination of outlying districts. To economize in the feeder investment for this work, Fred H. Smith, superintendent

of the company, devised a plan by which energy for the operation of each circuit is derived from the regular 2300-volt, single-phase commercial service of the plant. Each circuit of incandescent lamps contains from fifty to seventy-five lamps looped through a suburban zone from a constant-current transformer located in a pole box in the immediate neighborhood of the lamp district. The constant-current transformer is connected across the 2300-volt line, one side being fused and the other side connected through a solenoid switch, the actuating coil of which is in series with one of the company's regular street arc circuits passing the transformer case.

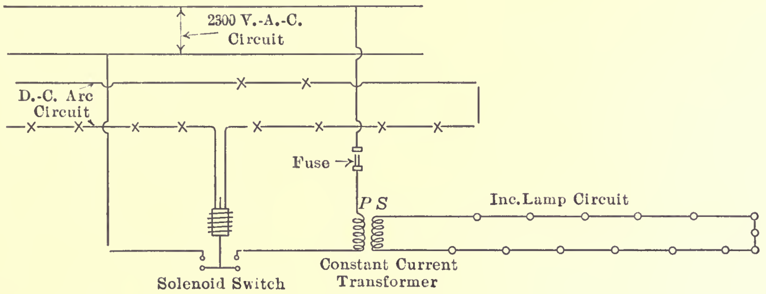


FIG. 1.—ECONOMICAL STREET-LIGHTING WIRING ARRANGEMENT.

The incandescent service is thrown on automatically at the time the regular arc service is switched into operation. The plugging in of the arc lamps permits current to pass through the solenoid switch coil in the pole box, thereby closing the contacts of the local constant-current transformer primary and starting the operation of the series incandescent lamps. In order to keep the incandescent circuit constantly in service regardless of the current fluctuations and regulation of the arc lamp circuit, a pole piece is installed in the core of the solenoid switch, so that the plunger is held firmly against it as soon as a starting current is passed through the arc circuit and coil. In the morning when the arc circuit is cut off the incandescent service remains on until an operator at the distributing substation utilizes alternating current to demagnetize the solenoid core and permit the plunger to drop and break the incandescent circuit. The solenoid switch is of the oil type. Fourteen incandescent circuits of this type are now in operation at Worcester, the load on each varying from 4 kw. to 10 kw. The effect upon the 2300-volt lines has been negligible, and by the use of the automatic switch, which is built for high-potential operation, no patrolman is required to handle the incandescent switching. The system, of which a diagram is presented in Fig. 1, has saved money in underground conduits, ducts and feeders, besides eliminating an expensive switchboard at the main distributing center.

All-day Supervision of Arc Circuits.—When the plug connectors are withdrawn from the switchboard jacks controlling arc-lamp circuits in the St. Louis substations test wires are plugged in their place, each pair lighting a couple of 4-c.p. lamps from the 220-volt bus through one of the outside arc-circuit loops. The test wires are formed up to length so that each enters its individual jack and makes connection with the test lamps correspondingly numbered. These test lamps are thus connected up all day, as long as the arc circuits are not in use. If a lamp goes out it is the duty of the station operator to call up the trouble department and notify it of the number of the circuit in trouble in order that repairs can be started without delay. The operator is also required to look at the test lamps once every hour, when he reads his meter, making a note of any circuits open. He must then call the trouble department and report whether or not all test lamps are burning properly. These calls must be made hourly whether trouble is present or not. This system of all-day supervision of arc circuits has greatly reduced the number of cases of trouble going undiscovered until nightfall. With the low voltage employed trimmers cannot get a shock of more than 220 volts, or 110 volts to ground, but they are instructed to wear rubber gloves when handling arc lamps on the street. The scheme is shown in Fig. 1.

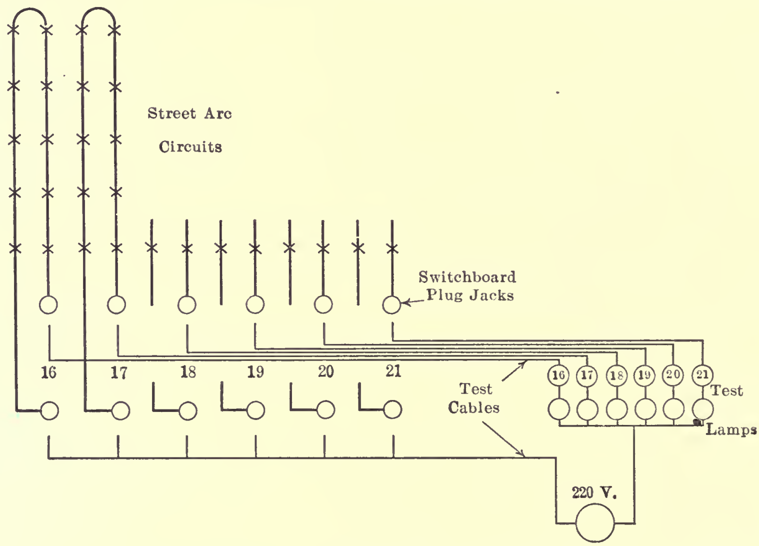


FIG. 1.—ALL-DAY SUPERVISION OF ARC CIRCUITS.

Automatic Control of Curb Lighting Fed from Edison System.—The business section of Dayton, Ohio, is lighted by 360 340-watt tungsten clusters, divided into seven groups, each fed at a convenient point from

the 220-volt Edison three-wire mains of the Dayton Lighting Company. Formerly controlled by hand from street switches, this lighting is now all manipulated practically simultaneously from the station switchboard, a magnet-switch scheme being used which has saved much of the wiring required with the usual distribution or pilot-wire controls. The scheme, which is due to O. H. Hutchings, general superintendent of the company, is illustrated in simplified form in Fig. 1. Closing one of the control switches at the right energizes the magnet contactor of a nearby section. As this section lights up, it in turn energizes the contactor of section No. 2, and the action is repeated throughout the system, until the lighting of the last section is indicated by the pilot lamps on the switchboard. One switch thus controls the four lower 60-watt lamps on the posts,

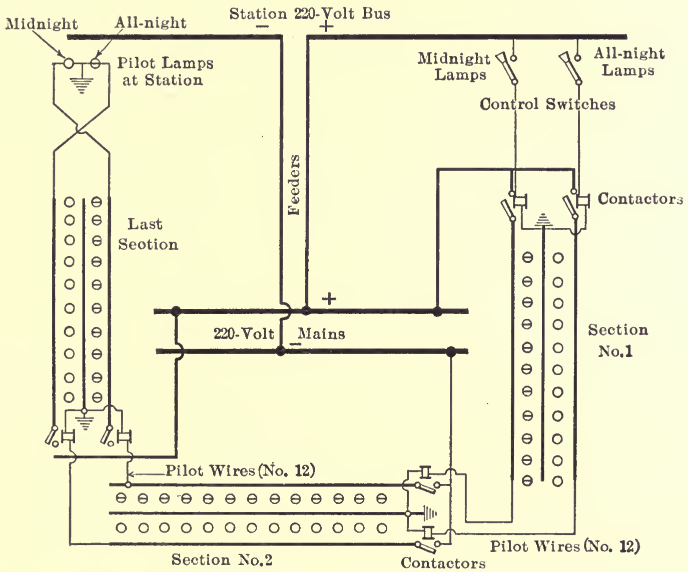


FIG. 1.—AUTOMATIC CONTROL OF CURB LIGHTING FED FROM EDISON SYSTEM.

operated till midnight; the other governs the single 100-watt units operated all night. Although not shown in the sketch to avoid complication, each group is itself balanced across the three-wire system, double-pole switches taking the place of the single contacts indicated. Individual sets of these 100-amp. General Electric carbon-break contacts are mounted, with the section fuses and meter, in the 30-in. by 34-in. gasketed manhole box installed at the feeding point of each section. The meters are read once a month and the switches are inspected and cleaned at this time. Each magnet winding consumes about 0.3 amp. at 110 volts in its holding position, and the contactors carry 58 amp. to 90 amp.

From the closing of the control switch to the flashing of the corresponding pilot lamp, barely one second is required for the impulse to traverse the seven switches and a total distance of 10,500 ft. Half of this path is in No. 12 pilot-wire circuit, the average length of pilot circuit being 785 ft. The system cost $120 per switch station to install, exclusive of meters, and now saves about one-half hour's daily operation, due to irregular lighting, or about 60 kw.-hr. per day, in addition to labor. Half a mile from the nearest post-lighting circuit, the Dayton company also lights a bridge with alternating-current multiple tungsten lamps, the control of which has been effected by extending a pilot circuit and magnet switch from the direct-current curb system, replacing an unsatisfactory time switch formerly used at the bridge. The cost of operating the curb system is $55 per 340-watt post per year.

Remote-Controlled Operation of Peoria's Ornamental Lighting.—The 240 five-lamp standards which light the downtown section of Peoria. Ill., are fed in groups of six to the curb block from the 110/220-volt

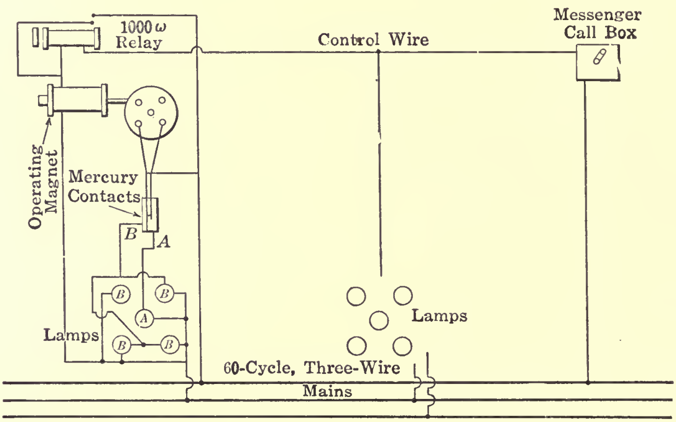


FIG. 1.—REMOTE-CONTROLLED OPERATION OF PEORIA'S ORNAMENTAL LIGHTING.

alternating-current three-wire mains and are turned on and off by means of a remote-control pilot circuit which operates relay switches at the feeding points. By an ingenious arrangement a step-by-step mechanism permits the four 60-watt lamps or the single 100-watt units to be turned positively on and off, independently of the others, although only a single control wire is used.

At each feeding point for a six-post block a relay switch is installed in a post base. It includes a 1000-ohm telephone relay, bridged between the control wire and the system neutral, and the 50-ohm switch magnet, whose winding is energized through the relay contact. This operating magnet works against the switch shaft, rotating it 90 deg. each time the

magnet is energized. Pitman rods from this shaft control contacts dipping into the two mercury cups, one for the top-lamp circuit and the other for the lower lamps. The crank pins for these rods are also quartered 90 deg., as the sketch shows, so that in succession both contacts may be down, or one up and one down, or both up. This series of positions is passed in the course of one rotation, lighting first the lower lamps, then the top lamps, then extinguishing the lower lamps and finally extinguishing the top lamps.

Some difficulty was at first experienced in timing the impulses to operate all the relays and switches positively, but the messenger call-box mechanism finally adopted solved this problem, the impulses now being fixed at about fifteen seconds' duration with five-second intervals. Another slight source of trouble has been the sensitiveness of the relays as first installed. A heavy blow to the switch post, such as a wagon riding over the curb, would cause a momentary closure of the contact, putting the corresponding circuit out of step. But these minor difficulties have been speedily cleared out, and each switch before being installed received a test of 500 operations without a single failure. The switch mechanism is inclosed in a 6-in. by 10-in. iron box, 2 in. deep, with fiber entry bushings for the wires. The outfits cost about $12 each as made in a local shop. The No. 10 control wire which operates the forty switches has a total length of about 3 miles. Each relay takes about 0.1 amp. and the operating magnets 2 amp. momentarily. C. A. Rich, foreman of the underground department for the Peoria Gas & Electric Company, devised the installation described.

Electric Lighting from Three-phase Circuits (By G. P. Hoxie).—It is prevalent practice to distribute electrical energy in industrial plants by means of the three-phase system, principally because of the simplicity and reliability of the induction motor. Although other voltages are used, 220 and 440 are the most common. Usually the proportion of the total energy generated required for lighting is small. Most of it is utilized for motor circuits and its adaptability for electric lighting is of secondary importance. Practically all lighting equipment operates only from single-phase circuits; but as a rule it is not advisable in industrial plants to generate single-phase current solely for lighting service. So some plan must be adopted whereby single-phase circuits for the operation of lighting equipment can be arranged from three-phase circuits.

One of the simplest schemes for lighting from a three-phase circuit is suggested in Fig. 1. Single-phase branches are tapped from the three-phase main and the voltage across each branch will be the same as that between any two wires of the main. In arranging circuits after the manner shown, the loads on the branch circuits should be so divided that each of the three phases will be about equally loaded. That is, phases

A, *B* and *C* (Fig. 1) should each serve groups of lighting appliances of approximately equal inputs. Fusible cut-outs should be inserted in each branch circuit where it branches from the mains.

In Fig. 1 the mains have a potential of 220 volts, therefore 220-volt incandescent and arc lamps can be fed from the branches. With 440-volt, three-phase mains it is not usual to connect single-phase lighting circuits direct to the mains. Some type of transforming device is interposed between the mains and the branch lighting circuits, as will be hereinafter described.

Carbon-filament incandescent lamps for 220 volts cost more than do similar lamps for 110 volts and they have shorter lives and are less efficient than are 110-volt lamps. Consequently in some installations, where three-phase energy is distributed at 220 volts, 110-volt carbon

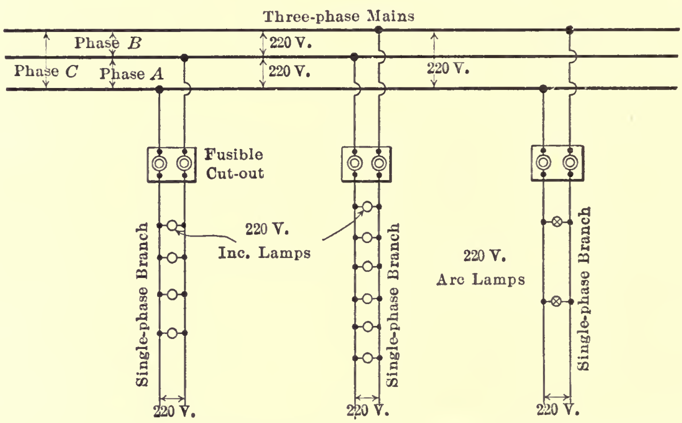


FIG. 1.—MULTIPLE SINGLE-PHASE CIRCUITS FROM THREE-PHASE CIRCUITS.

incandescent lamps are operated two in series as indicated in Fig. 2. In these installations multiple arc lamps are used that are built for operation on 220 volts. Metallic-filament lamps for 110 volts are cheaper, more efficient and have longer lives than similar ones for 220 volts and have more rugged filaments, hence are less liable to breakage. For these reasons metallic-filament lamps are sometimes connected as outlined in Fig. 2. When ordering metallic-filament incandescent lamps that are to be operated two in series it should be specified in the order that the lamps are for series operation so that they can be especially selected for this service. Metallic-filament lamps are designated by their nominal inputs in watts and two lamps of the same nominal input may vary considerably in actual input. If two such lamps, having different inputs, are connected in series across a circuit of twice their nominal voltage, one of the lamps may be considerably overloaded and will have a correspondingly shorter life.

Two plans for wiring buildings for motors and lamps using three-phase sub-mains are shown at *A* and *B*, Fig. 3. The lighting panel box used is shown in Fig. 4. Both of the buildings are served from the three-phase main in the street in front of them. In the plan *A* energy for both lamps and motors is taken from the same sub-main which traverses the

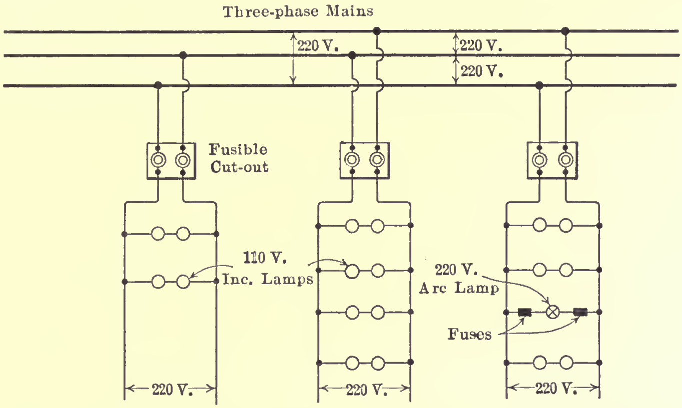


FIG. 2.—SERIES-MULTIPLE SINGLE-PHASE CIRCUITS FROM THREE-PHASE CIRCUITS.

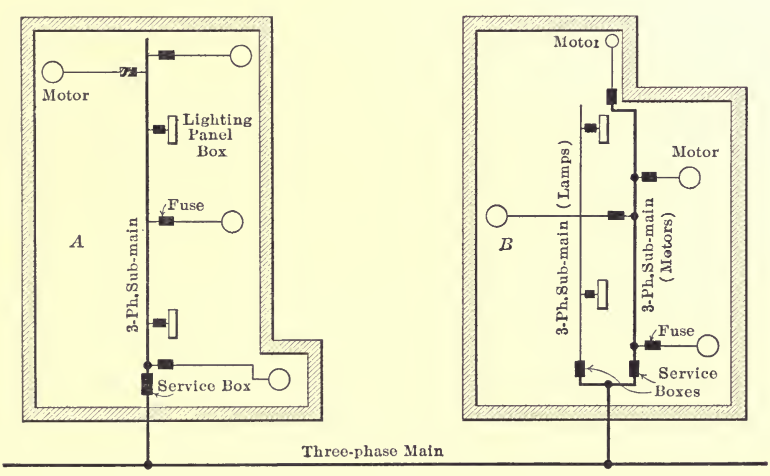


FIG. 3.—WIRING FROM THREE-PHASE MAINS.

center of the building, while at *B* individual sub-mains are arranged for lamps and for motors. Where it is essential that the wiring be installed economically and the motors served are of small size the plan indicated at *A* can be used; but where a first-class installation is desired it is better to divide the lamp and motor sub-mains as suggested at *B*. The disad-

vantages of plan *A* are (1) that the heavy momentary currents, drawn by the motors at times of starting or of changes in load, may cause poor voltage regulation and the consequent unsteadiness of light, and (2) that trouble on the motor circuits may melt the main fuse and extinguish all of the lights. It is assumed for plans *A* and *B* that the voltage regulation on the main in the street is good. With plan *B* conditions on the motor circuits cannot to any extent affect the regulation on the lighting sub-main, as it is independent and the fuses protecting the motor sub-main can melt without extinguishing the lights, because only energy for motors feeds through them.

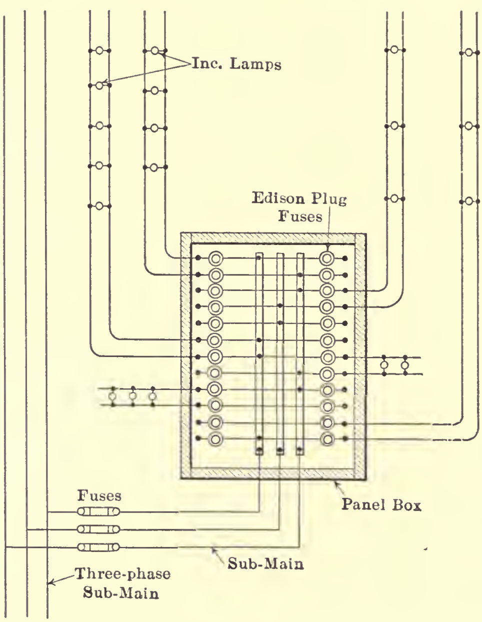


FIG. 4.—THREE-PHASE TO SINGLE-PHASE PANEL BOX FOR LIGHTING SYSTEM.

In Fig. 4 is delineated a method of arranging a panel box that might be used in plan *A* or *B*, Fig. 3. Three conductors are "tapped" to the three-phase sub-main and carried, through fuses, to the three busbars of the panel box. In the panel box the single-phase branch circuits are connected successively across each of the phases, in rotation, so that the lighting load will tend automatically to balance itself. Edison plug cut-outs are interposed between the busbars and the terminals of the single-phase branch circuits. The scheme of connections indicated in the panel box of Fig. 4 is merely an elaboration of that suggested in Figs. 1 and 2. In Fig. 4, if the sub-mains operated at 220 volts, 220-volt incandescent lamps would be used, or 110-volt lamps might be used in

groups of two in series like the arrangement of Fig. 2. If the sub-main pressure was 110 volts, 110-volt lamps would be used on the branch circuits. If the voltage on the sub-main was 440, some other method would be utilized as hereinafter outlined.

A three-phase distribution system for an industrial plant is indicated in Fig. 5. An individual three-phase feeder is carried from the generating station to each of the buildings on the property. Just within each of the three larger buildings, Shops I, II and III, the feeder, after passing through a service switch and fuses, is divided and carried into a distribution box for motor circuits and into one for lamp circuits. The store-

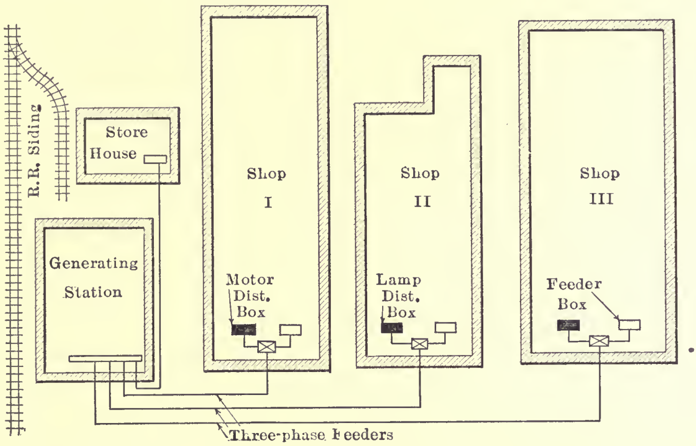


FIG. 5.—A THREE-PHASE DISTRIBUTION SYSTEM.

house is served by a small feeder terminating in a lighting distribution box. If the buildings have but one story, motor branch circuits might feed direct from the distribution boxes, or mains might be carried from them the length of the buildings and motor branch circuits would be connected to the main as outlined at *B*, Fig. 3. Lighting circuits, if the buildings of Fig. 5 were all of one story, might be arranged as detailed in Fig. 3, *B*, and Fig. 4. If the buildings were of more than one story, the plan of Fig. 6 could be adopted. In this diagram fuses and switches are not indicated. From the feeder box mains are carried to the distribution boxes, for motor and for lamp circuits, which are located in the basement. From the distribution boxes risers are carried through the floors above and panel boxes are located on each floor. Only one set of risers and panel boxes is indicated in Fig. 6, but with a building covering a large area several sets, duplicates of those shown, might be necessary. The distribution boxes in the basement would, in such a case, be so arranged that all of the risers—which would be mains—would feed from

them. It might be desirable in some instances to carry individual mains from one of the distribution boxes to each of the panel boxes or to a group of two or three panel boxes. This plan would probably be followed, particularly with the electric-light circuits, if a building of six

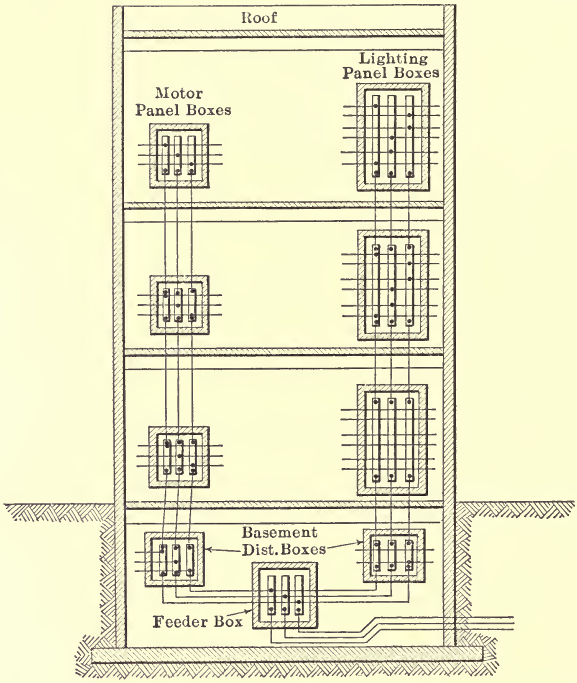
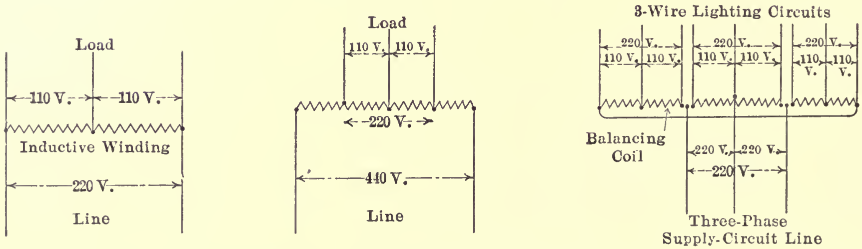


FIG. 6.—PLAN OF WIRING FOR BUILDING OF SEVERAL STORIES.



FIGS. 7, 9 AND 10.—DIAGRAMS OF THREE-PHASE AUTO-TRANSFORMER, THREE-WIRE, 440-VOLT AUTO-TRANSFORMER AND THREE-WIRE SYSTEMS BALANCED ON A THREE-PHASE SYSTEM.

stories or over were being wired. The reason for this is that circuits can be designed to provide closer voltage regulation if small groups of boxes—rather than large groups—located reasonably close together are each fed with an individual main.

Because they are very economical of copper and permit the use of individually fed 110-volt incandescent lamps (instead of two 110-volt lamps in series) 110–220-volt three-wire circuits are very extensively used for distributing electrical energy for interior lighting. Three-wire-110–220-volt alternating-current circuits can be obtained from 220-volt, single-phase, alternating-current circuits with an auto-transformer as shown in Fig. 7. How this principle is applied to three-phase circuits will be shown later. Auto-transformers for this and similar services are regularly manufactured and are usually arranged in standard transformer cases as suggested in Fig. 8. The load on such an auto-transformer is

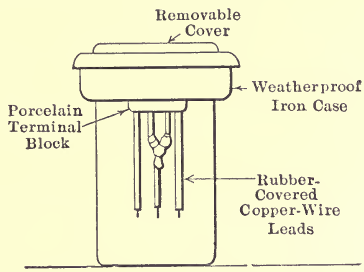


FIG. 8.—AUTO-TRANSFORMER.

equal to the difference in the loads on the two sides of the three-wire system and the size of the auto-transformer to be used can be determined accordingly. For example: If the load on one side of a three-wire system, like that of Fig. 7, were 100 amp. and the load on the other side were 150 amp. the auto-transformer would be loaded with but $150-100=50$ amp. The amount of unbalance that should be provided for in each case—hence the size of the auto-transformer—is determined by local conditions. If there is probability of great unbalance and if the lamps must be kept burning at any reasonable cost, it should be assumed that one side of the three-wire system may be fully loaded while there is no load on the other side. This would mean that the auto-transformer should have a rating equal to the entire load on one side of the three-wire system. However, in practice the amount of unbalance does not, where branch circuits are carefully laid out; often exceed 10 per cent. of the total load. On this basis the rating of an auto-transformer should be 10 per cent. of the total load to be connected to it. In some installations the amount of unbalance on a three-wire system is very small, not exceeding 5 per cent. at any time. But in other cases the unbalance may be as high as 15 per cent. or even 30 per cent. A 10 per cent. unbalance is probably a fair average working amount.

If an auto-transformer is selected on the basis of slight unbalance, say 10 per cent. and the unbalance becomes excessive, not very much

can happen if all circuits are properly protected by fuses. Voltage above normal may for a time be impressed on the lamps on one side of the three-wire system if a fuse is melted by overload, or currents may flow that are great enough to melt fuses, extinguishing or dimming the lights. But these difficulties reveal themselves, are readily corrected and ordinarily do no serious harm.

Inasmuch as auto-transformers can be purchased that are mounted within weatherproof cast-iron cases they can be arranged on the outside walls of buildings or on poles. Apparently there are no specific rules governing the installation of large auto-transformers, or balance-coils as they are sometimes called in the National Electrical Code. For this reason it would probably be best to confer with the local inspection bureau before making an installation to find just what the district representative would require. It is probable that the rules that govern the installation of transformers would also govern the installation of auto-transformers. That is, they must not be placed inside of buildings, except stations and substations, without special permission, and when they are placed inside of buildings certain precautions must be taken to prevent the spread of fire in the event of the oil in the cast-iron case becoming ignited. A fireproof inclosure of some sort, well ventilated to carry away oil fumes, would probably be required in buildings other than stations and substations.

Three-wire circuits are, with auto-transformers, obtained from 220-volt, three-phase circuits by connecting an auto-transformer, like that of Fig. 7, across any one or across each of two or of the three phases. In Fig. 10 a diagram is shown of three auto-transformers, each serving a three-wire circuit and each connected across one of the three phases. Three-wire 110–220-volt circuits can be obtained from any one of the phases of a 440-volt, three-phase system by using an auto-transformer such as that indicated diagrammatically in Fig. 9. Equipment for this service can be purchased from any of the principal builders of transformers.

Transformers can, of course, be used for any application shown herein for auto-transformers. But, as a rule, transformers for a given application will be more expensive than auto-transformers. This is because a transformer has two windings, a primary and a secondary, and because a transformer must always have a rating equal to the full load on the three-wire system. It should be noted that an auto-transformer, arranged between a single-phase and a three-wire system, must have sufficient rating to accommodate the full load current in the line wires of the single-phase system unless the voltage across the outside wires of the three-wire system is impressed on the auto-transformer. For example, an auto-transformer operating as indicated in Fig. 7 need not necessarily be of sufficient size, to accommodate the primary current in the 220-volt

line, while the auto-transformer suggested in Fig. 9 must be of a rating to accommodate the primary current in a 440-volt line. Transformers possess one advantage over auto-transformers. With auto-transformers the secondary circuits are electrically connected to the primary circuit and a ground on the secondary circuit may have the same effect as one on the primary circuit. Furthermore the secondary circuits are at primary potential above ground and may give a severe shock to a person coming in contact with them if there is a ground on the primary circuit—and there usually is. With the transformer there is no electrical connection between primary and secondary circuits, so neither of the above objections holds.

When auto-transformers are used on three-phase circuits to feed three-wire systems they should be connected on the three phases as outlined

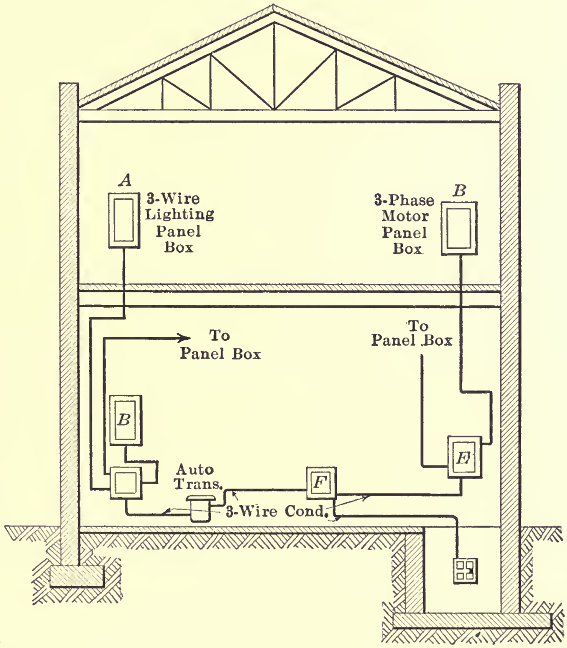


FIG. 11.—AUTO-TRANSFORMER FOR LIGHTING OF FACTORY BUILDING.

in Fig. 10. The three-wire mains and the branch circuits for lighting should be so loaded that each phase will be almost equally loaded. Some unbalancing will not appreciably affect the operation of the three-phase system. Just the amount of unbalancing that would be permissible is determined by the characteristics of the three-phase generator, the load on it, and by the character of the equipment connected to the three-phase circuits. It is probable that, with the average generator, there

can be, when it is operating at about full load, a load unbalance of possibly 25 per cent. between the most lightly and the most heavily loaded phases without the voltage regulation being affected enough to make trouble.

Suggested in Fig. 11 is an arrangement of equipment in an industrial building whereby three-wire, 110–220-volt lighting circuits are fed through an auto-transformer from a three-phase feeder. On entering the building from the subway, the three-phase feeder enters a feeder box where mains are branched from it. One phase only, for lighting, continues to the auto-transformer, and the other three-phase branch

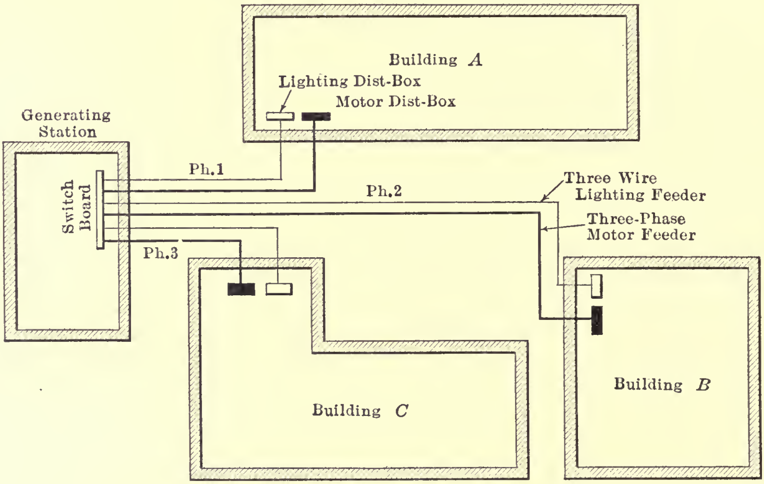


FIG. 12.—LIGHTING AND MOTOR FEEDER LAYOUT.

for motor circuits is carried into the three-phase distribution box. From this box mains are carried to panel boxes located about the building. From the auto-transformer the three-wire main enters the three-wire lighting distribution box. From this box three-wire mains are run to lighting panel boxes situated in the various departments in the structure. From the panel boxes single-phase branches are brought out and to these branches the electric lamps are tapped. The method of Fig. 11 resembles somewhat the scheme indicated in each of the buildings of Fig. 5. The difference is that in Fig. 5 the lighting mains are three-phase while in Fig. 11 they are three-wire.

A single auto-transformer, like that in Fig. 11, on one phase of a three-phase system might unbalance the system excessively, but this can be avoided by installing auto-transformers in other buildings on the other phases. The connections for the auto-transformer in Fig. 11 are shown in Fig. 9.

It is, as hereinbefore outlined, often desirable to install individual feeders for lamps and for motors. This applies whether auto-transformers are used or not. In Fig. 12 is shown the feeder layout for a manufacturing plant generating 220-volt, three-phase energy and using

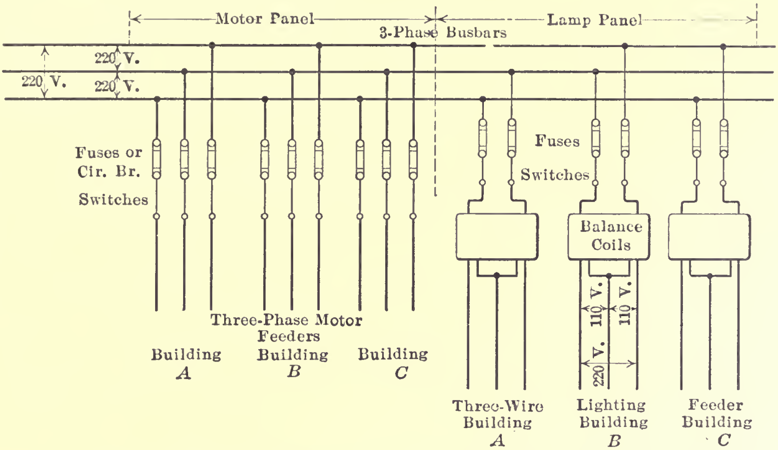


FIG. 13.—THREE-WIRE THREE-PHASE CIRCUIT FOR MOTORS AND LAMPS.

separate feeders for motor and for lamp circuits. The pressure on the three-phase motor feeders is 220 volts and that on the lighting three-wire feeders is 110–220 volts. Auto-transformers connected as shown

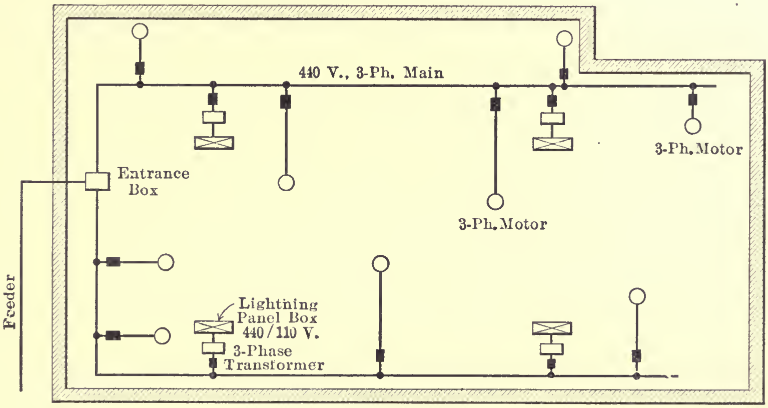


FIG. 14.—LIGHTING CIRCUITS FED THROUGH TRANSFORMERS.

in the feeder diagram, Fig. 13, are utilized to obtain three-wire circuits from the three phases. The notation on this diagram corresponds with that on Fig. 12 and indicates how the motor and the lamp feeders are apportioned.

In at least one factory the method of lighting from three-phase circuits shown in Fig. 14 has been used. The three-phase mains operate at 440 volts and at each lighting panel box a transformer is installed which reduces the pressure to 110 volts for the lighting circuits. Three-phase busbars, fed by the transformer secondaries, are arranged in each box and from these buses single-phase branches are tapped. The connections within the lighting panel boxes are substantially the same as those indicated in Fig. 4. Three-phase motors operate from the same mains that supply the lighting energy.

Low-frequency Flicker Cured By Two-phase Wiring.—In a large manufacturing establishment near Pittsburgh the shop offices are lighted from the 25-cycle plant lines. At this low frequency the 40 watt tungsten lamps used gave considerable annoyance from flickering. The units were hung low, and at the high intensities on the working

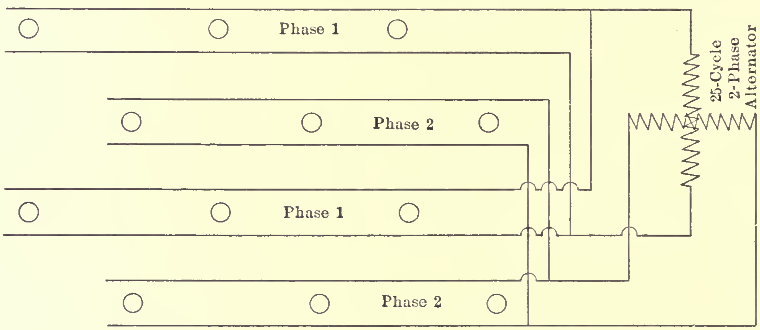


FIG. 1.—LOW-FREQUENCY FLICKER CURED BY TWO-PHASE WIRING.

surfaces this flicker became very objectionable. The trouble was practically cured, by connecting half of the twenty lamps to the second phase of the two-phase supply system. The individual flicker of each group is thus neutralized by the coincident "peak" of the other lamps, and the total illumination on any lighted surface is practically uniform. On examination, of course, the flicker of the individual lamps can still be detected. The second phase was, in the case cited, easily accessible, and the division of the load, besides curing the flicker, has resulted in a better balance. The method is shown in Fig. 1.

Testing Lamps by a Motor-driven Machine.—The home-made lamp-testing machine used by the Edison Electric Illuminating Company of Boston, Mass., has the special advantages of increased speed with which lamps can be tested, as compared with former hand methods, and the use of an automatic counter which insures accurate enumeration of all lamps passed through the apparatus. The device consists of an endless belt carrying about two dozen sockets spaced at 6-in. distances, three driving

pulleys and a small 110-volt motor. Two brass contact strips 3/4 in. wide are provided for a distance of about 2 ft. below the upper belt at the left-hand end of the machine. Lamps returned from customers' installations are placed in the sockets, and as the machine operates they pass rapidly from right to left, each base actuating the counter and being made alive as the upper portion of the belt passes over the brass contact strips. The belt is 3 in. in width and runs over the contact strips just long enough to enable an operator at the left of the machine to see whether each lamp burns properly or not.

Lamps which burn properly on this test are culled from the rest and, after being photometered into two grades, are installed in various company buildings, in portions of its power plants and substations, or sent to contractors for the rough usage of field work. The usual capacity of the machine is about 3000 lamps per day, with one man working at each end but it has a maximum of seventy lamps a minute.

Wiring for Extension Lamp in 600-volt Series Circuit.—The plans for the wiring of a new railway substation called for extension outlets so arranged that five lamps would be in series across 600 volts, the fifth

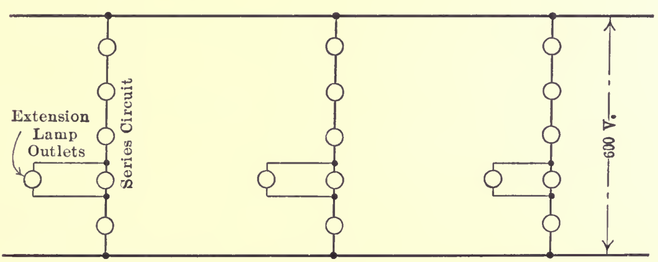


FIG. 1.—WIRING FOR EXTENSION LAMP IN 600-VOLT SERIES CIRCUIT.

lamp being the portable extension outlet and the other four being stationary. The arrangement finally adopted was, therefore, to shunt duplicate outlets in parallel with the portable outlet of the regular series circuit. To operate an extension lamp at any point it is thus only necessary to plug into the desired receptacle, at the same time backing out or switching off the other lamp in multiple. The diagram of connections appears in Fig. 1.

Inexpensive Lamp Guard for Interurban Cars.—Following the installation of tungsten lamps on its interurban cars operating between Fort Wayne, Ind., and Lima, Ohio, the Ohio Electric Company discovered that a large percentage of lamp breakage was due to the careless passenger who tossed his suitcase, grip or parcel into the parcel rack without noticing the tungsten lamp above the rack. A number of small steel rods 3/16 in. in diameter were therefore bent as shown in the drawing,

Fig. 1, and flattened at each end to receive holes for the wood screws which hold them in place. These rods, when fastened to the woodwork of the car above the advertising space, protect the lamps and are said to have reduced the breakage from the above cause without in any way impairing the efficiency of the illumination or obstructing speedy lamp renewals. The cost of the guards was found to be slight in comparison with former lamp bills.

Types and Uses of Semi-indirect Lighting Units (By Leonard V. James).—The tendency in modern lighting installations is undoubtedly toward diffused illumination, together with an effort to add to the appearance of the room by the use of proper fixtures. Direct lighting from un-

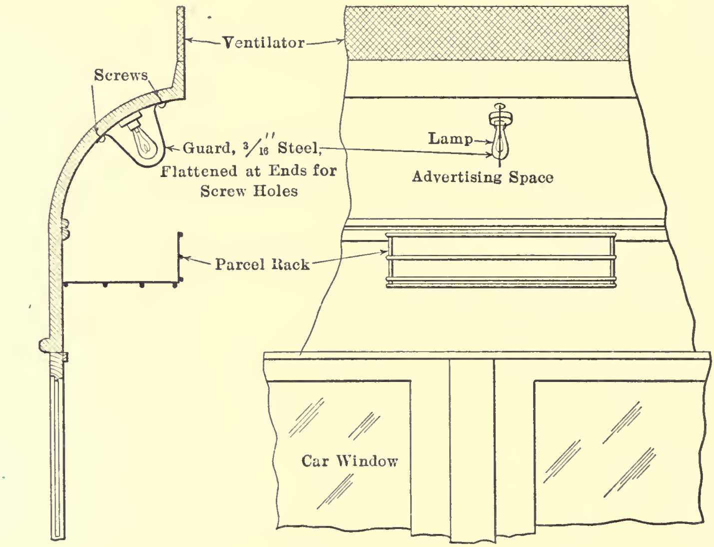
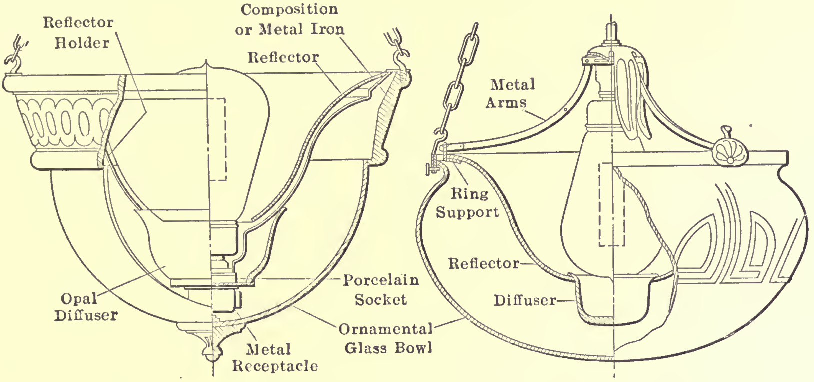


FIG. 1.—LAMP GUARD FOR INTERURBAN CARS.

shaded sources and indirect lighting with all of the light-flux reflected to the working plane from a diffusing surface are the extremes. Approaching the direct lighting there is the type of unit in which the light source is shielded by shades ranging from nearly clear glassware to translucent bowls and finally to opaque mirrored reflectors, all of these having a more or less directive effect. The so-called semi-indirect system is really a special case of the modified direct, since the most of the useful light-flux passes through the translucent bowl.

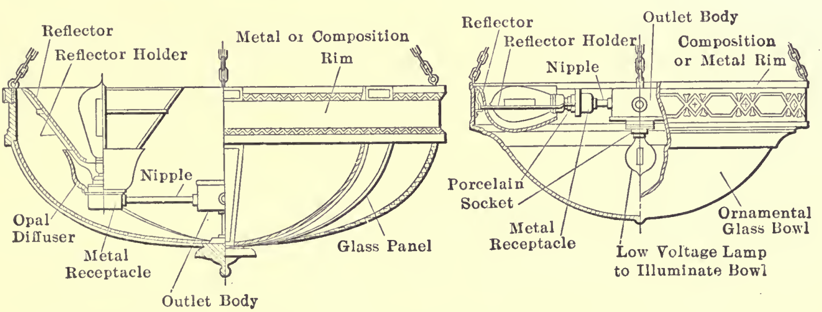
The combination of the direct and indirect lighting furnished by the luminous-bowl units is effective and pleasing and meets the public demand for indirect lighting together with an apparent light source. In a paper read before the Illuminating Engineering Society in June, 1912,

Thomas W. Rolph discusses the results of a series of tests, suggesting that the illumination of the ceiling with indirect lighting is from 10 to 15 per cent. as intense as that of a direct-lighting fixture producing the same effect in the room. These results seem to have been verified by the manufacturers of the luminous-bowl fixtures under discussion, as the light-flux used in securing the desired effect appears in all cases to be almost exactly 10 per cent.



FIGS. 1 AND 2.—LAMPS AND REFLECTORS IN VERTICAL POSITION.

There are two arrangements of the interior equipment used in the fixtures in question. As a rule the reflectors and lamps are in a vertical position, as shown in Figs. 1, 2 and 3. The reflectors used are one-piece



FIGS. 3 AND 4.—LAMPS AND REFLECTORS IN VERTICAL AND HORIZONTAL POSITIONS.

silvered-glass opaque reflectors. The light-flux which illuminates the outside bowl passes through and is directed by an opal diffuser, located so that it interferes but little with the normal reflection required for general illumination. Fig. 4 shows the arrangement used when shallow bowl fixtures are employed, it being necessary here to install the lamps and reflectors in a horizontal position. The small lamp which lights the

bowl is suspended at the center of the equipment and usually consumes about 10 per cent. of the total wattage of the fixture. Note that in all cases the equipment is suspended from the edge of the fixture.

A very artistic effect can be secured by properly choosing the patterns and colors employed, the color of the bowl being determined either by that of the glass or that of the illuminating bulb.

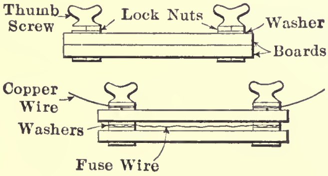
Cleaning is accomplished in the single-unit fixture by releasing the chain at one of the suspension points. In the multi-unit fixture the reflectors are readily accessible in their normal positions except where horizontal as in the case of the shallow-bowl equipment, where they may be released by a spring catch and tilted into an accessible position. These reflectors have a fire-glazed inner surface so that dust may easily be removed with a damp cloth. Should it be necessary to clean the bowl, it can be released either by set-screws or the entire interior equipment can be lifted clear of the bowl.

VIII

TRANSFORMERS, OIL SWITCHES AND CIRCUIT-BREAKERS

Testing, Operation and Arrangements of Transformers, Protection of Secondary Networks, Maintenance of Oil Switches and Circuit-breakers

Testing Transformers for Insulation (By T. W. Poppe).—Central-station managers in small towns are often worried about the possible breakdown of the insulation of transformers, which might cause fires in buildings by coming in contact through the house wires, with gas pipe at the outlet of the chandelier or other possible grounds or shock customers in the act of turning on the circuit at a brass lamp socket. All transformers should, therefore, be tested occasionally to make sure the insulation is perfect. This should be done when the transformer is inspected to see if the proper amount of oil surrounds the windings. It is then a simple and easy matter and should not be neglected. The following is a



FIGS. 1 AND 2.—TESTING TRANSFORMERS FOR INSULATION.

description of how transformers can be tested on the ordinary 2300-volt line, disconnecting the consumer from service only a few minutes if the transformer insulation proves to be sound. It it proves otherwise it is well to disconnect the transformer from service for such time as is required to install a new one. Fig. 1 shows a handy fuse block suitable for this purpose. It is constructed of two pieces of wood 1 in. thick, 3 in. wide and 12 in. long. The two pieces of wood are clamped together, as shown, by means of thumb-screws and bolts. Between these blocks and fastened as shown in Fig. 2 a piece of 1/4-amp. or 1/8-amp. fuse wire 10 in. long should be fastened. Under the locknuts and washers shown in Fig. 2 a piece of copper wire should be attached. This forms a cheap, ready-made fuse block which can be thrown about without danger of breakage. The lineman can readily fasten it to his belt by means of the copper wire when climbing the pole. The fuse block should be attached

to one of the primary wires and to one of the secondary wires, as shown in Fig. 3. Should the secondary be connected to ground the ground connection should be disconnected. In small towns the secondary is rarely connected to ground. Were the ground connection allowed to remain in place while making a test the result might be misleading should a ground exist on the opposite primary line. After connecting the fuse block as shown the fuse plug No. 1 protecting the transformer should be withdrawn from its receptacle. Should the insulation of the transformer

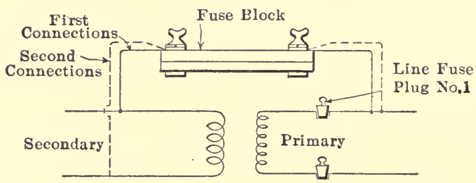


FIG. 3.—TESTING TRANSFORMERS FOR INSULATION.

be defective the current would flow through the defect into the secondary coils and through the fuse wire into the other primary line. This would cause the fuse to blow, showing that the transformer insulation is defective. No fear need be felt about throwing a short-circuit on the line through the fuse block, as the load 1/8 amp. or 1/4 amp. would do no harm should the insulation allow the current to flow. The connection to the primary line should now be transposed, placing it upon the other primary line, withdrawing fuse plug No. 2 and reinstating fuse plug No. 1. This is done because it is possible that a slight defect may exist in a part

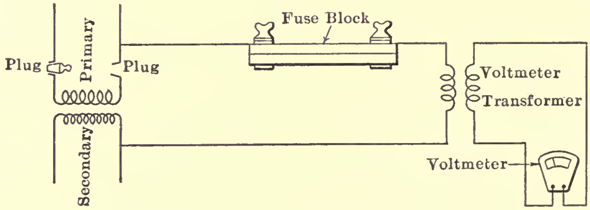


FIG. 4.—TESTING TRANSFORMERS FOR INSULATION.

of the windings which might have sufficient self-induction to choke the circuit when connections to the first primary line are made. When the transposition is made it lessens the self-induction and should the defect exist the fuse will blow. Should one fear using the fuse block the same connections can be made by using the fuse block in series with a voltmeter and shunt transformer as shown in Fig. 4. This would be absolutely safe, but a low reading on the voltmeter should not be neglected, as it indicates that a defect exists and should be attended to.

Current-ratio and Phase-angle Test of Series Transformers (By H. S. Baker).—The method here described for determining the current-ratio and phase angle of series transformers consists in bucking a known multiple of the primary amperes against another known multiple of the secondary amperes and reading the vector difference upon a wattmeter. The only apparatus required consists of a wattmeter of the moving-coil type, an ammeter, a laminated iron ring upon which may be wound

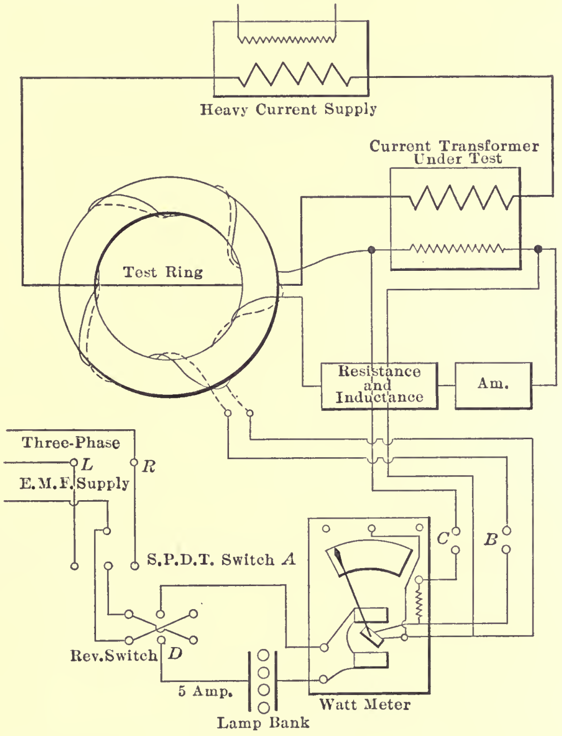


FIG. 1.—CURRENT-RATIO AND PHASE-ANGLE TEST OF SERIES TRANSFORMERS.

various numbers of turns of wire, and a lamp bank. There must also be available a source of polyphase e.m.f., a source of heavy current and switches, as shown in Fig. 1.

The procedure of test is as follows: The apparatus is connected as shown in Fig. 1. The test ring shown has one primary turn, with secondary turns, shown in full line wound approximately uniformly around the ring. The tertiary winding, shown in dotted line, is also wound approximately uniformly around ring. This tertiary winding feeds through the switch *B* directly into the moving coil of the wattmeter.

Voltage taps are taken off at the secondary terminals of the transformer under test and connected through the switch *C* to the moving coil of the wattmeter through the regular meter resistance shown. The series coil of the wattmeter is supplied with 5 amp., which may be taken from either of two e.m.f. phases through the switch *A*, and may be reversed at will by means of the switch *D*.

Current is supplied through the heavy current circuits as shown. Care should be taken that the primary and secondary amperes are bucking in the test ring and not adding. The switches *A* and *B* are closed to the right and the switch *D* closed in the direction giving a plus deflection on the wattmeter. If *D* is to the right the reading may be designated plus and if to the left minus. The switch *A* is then closed to the left and another reading taken.

The above two readings represent components of tertiary amperes along directions of the two e.m.f's. used. The series secondary terminal voltage may now be read as follows:

Close the switches *A* and *C* to the right and the switch *D* in the direction to give a plus deflection of the wattmeter. Read the wattmeter and then throw switch *A* to the left and repeat the reading. These two readings represent components of secondary terminal volts along the same two directions.

The above four readings were as follows in the case of a series transformer marked 400 to 5 amp., a test ring with two primary turns being used:

Ring secondary turns	Secondary amperes	Tertiary current		Secondary volts	
		R	L	R	L
161	3.6	−89	−22	+4.0	+1.3
162	3.6	−22	+46	+4.4	+1.6
163	3.6	+47	+118	+4.9	+2.0

Fig. 2 is a diagram in which the above readings are plotted for 161, 162 and 163 turns. The lines *OR* and *OL* are 60 deg. apart, representing two sides of the three-phase e.m.f. supply shown in Fig. 1. *OL* was assigned the e.m.f. phase which leads *OR* in order to give the diagram correct rotation. The point 161 was determined by measuring along *OR* a distance (see table) of minus 89 and erecting a perpendicular to *OR*, then measuring along *OL* a distance of minus 22 and erecting a perpendicular to *OL*.

The intersection of these perpendiculars gives the point 161, and the vector *O*—161 is the only line having projections along *OR* and *OL* of the values of minus 89 and minus 22. This vector thus represents the current flowing in the tertiary winding when 3.6 amp. are in the secondary

of the transformer under test, and when 161 to 2 is the ratio of the turns on the test ring. Similarly, the points 162 and 163 are plotted from the corresponding readings.

It will be seen that adding one turn to the secondary of the test ring changes its secondary amp.-turns in magnitude but not in phase, and in going from 161 to 162 the point has passed O. At the interpolated point 161.81 the vector $O-161.81$ is at right angles to the secondary amp.-turns of the test ring. This is the vector difference between the primary and secondary amp.-turns of the test ring. At this point the test ring

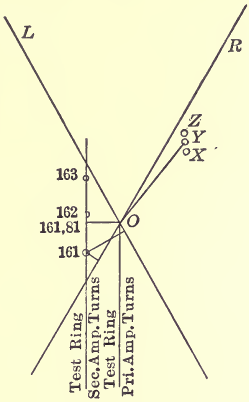


FIG. 2.—CURRENT-RATIO AND PHASE-ANGLE TEST OF SERIES TRANSFORMERS.

secondary and primary amp.-turns are of closely equal magnitude because their vector difference is approximately perpendicular to both. We know then that the vector ratio of currents is 2 to 161.81, or the current ratio is in error by $1.81 \div 160$, or 1.13 per cent.

The phase difference between the primary and secondary amperes is determined by measuring the distance $O-161.81$ and dividing it by 161.81 times the distance $161-162$, which operation gives the tangent of the angle of secondary current lead.

The voltage delivered by the transformer under test is determined by plotting the voltage points x, y and z from the above voltage readings and interpolating between x and y in the same ratio as the point 161.81 is between the points 161 and 162. The voltage at this interpolated point will be found to be 4.4 volts. The secondary amperes were taken as 3.6. The following data are then obtained for this point:

Secondary amperes	Secondary volts	Ratio	Phase lead
3.60	4.4	$\frac{161.81}{2}$	$\frac{0.89}{161.81}$

Other points taken on this same test were as follows:

1.64	$\frac{162.22}{2}$	$\frac{1.33}{162.22}$
1.45	$\frac{162.53}{2}$	$\frac{1.57}{162.53}$

The above test of three points on the ratio curve was carried out and plotted by convenient means in forty minutes and forms a method at once available and effective.

Bridged Spark-gaps Protect Transformer Coils (By L. N. Parshall). —Much trouble was formerly experienced on the transmission line which connects St. Paul, Minn., with the Somerset (Wis.) water-power plant of the St. Croix Power Company, due to transformer coils puncturing and burning out. With the occurrence of lightning discharges the end turns of the coils would break down, although the damage was usually

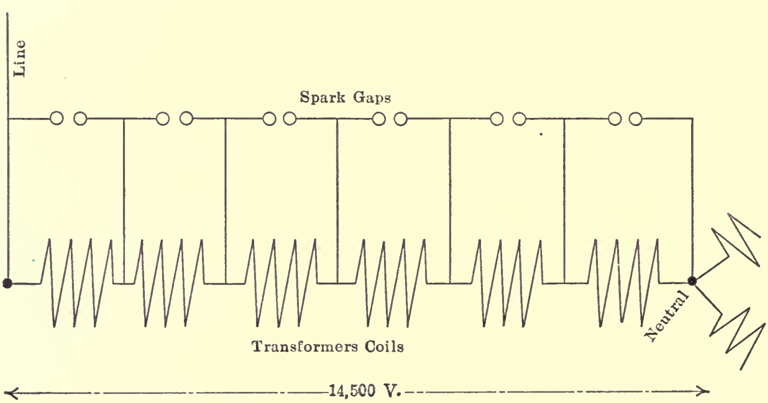


FIG. 1.—BRIDGED SPARK-GAPS TO PROTECT TRANSFORMER COILS.

localized there. Attempts to provide increased insulation at these points availed nothing. It was noticed that either the coils nearest the line side or those nearest the neutral tie were most affected, the middle sections rarely suffering. Further observation showed, too, that the line-side coils usually stood the brunt of the damage. The transformers were 500-kw., six-coil units, star-connected, as shown in Fig. 1, with 8000-volt primaries and 14,500-volt secondaries arranged to give a delta pressure of 25,000 volts. At the suggestion of F. R. Cutcheon, electrical superintendent of the St. Paul Gas Light Company, and John Pearson, superintendent of the St. Croix plant, the experiment was finally tried of connecting lightning-arrester spark-gaps across the coils as shown,

using five-gap arresters to bridge each 2400-volt interval. These gaps are set to discharge just above the normal working pressure on the coil. Use of the arresters after several years' experience has proved the practical solution of the former trouble from puncturing. Any potential that accumulates across the initial coils is discharged by the gaps before its pressure can rise to a point to rupture the insulation. Proof of this protective action is given by the sparks which from time to time are seen to pass across the outside gaps, while the remainder of the group is silent.

Protecting Secondary Networks against Defective Transformers (By S. D. Sprong).—In approaching the problem of eliminating a defective distributing transformer on primary circuits without allowing it to remain as a short-circuit on the secondary network, the author dismissed from consideration differential relays with contacts and all other devices suitable for interior work. This process of elimination left but one protective device that might be employed, namely, the fuse; but unfortunately the fuse has no sense of discrimination in the direction of the flow of current. Therefore it remained to utilize the fuse in such a way as to make it respond to reverse power, regardless of direction. Apparently the only means of doing this was to superpose on it a current resulting only from the reversal of load. It then remained so to connect this fuse that when ruptured by reverse power it would disconnect the transformer secondary from the network. This was accomplished by connecting the transformer to the center of the fuse and one of its terminals respectively.

The connections of the device for a three-wire network are shown in Fig. 1. The commercial transformer is shown at A, one terminal of the primary being connected in series with a coil B of the series instrument transformer. The terminals of the secondary of the commercial transformer are connected through coils C and C_1 on the series transformer. These latter coils are connected to the middle point of the looped fuses D and D_1, one side of which is connected from E and E_1 to the outer conductors of the three-wire network. The fuses D and D_1 act as a short-circuit connection on the coils E and E_1. Under normal conditions the primary B and secondary coils C and C_1, having the same ampere turns and being connected in opposition, will neutralize each other so that there will be no m.m.f. circulating in the core of the series transformers to energize the coils E and E_1. This balance of conditions is maintained at all loads and is upset only by a reverse current flowing from the secondary network into the transformer such as is occasioned by a short-circuit in the latter. Such a condition reverses the relative polarity of the coils C and C_1, thus energizing the core and causing a heavy short-circuit current to flow through the coils E and E_1 by way of the short-circuiting fuses D and D_1. The heavy

short-circuit current through the fuse immediately ruptures them and isolates the main terminals at G and G_1.

This device has been built and tested in transformers ranging from 5 kw. to 50 kw., two-wire and three-wire. It operates so nearly instantaneously that it does not blow the primary fuses in transformers immediately adjacent. The fuses D and D_1 each carry the secondary current and under normal working conditions are so proportioned that they will not blow from overload. Their current-carrying capacity compared with the full load of the transformer is not less than five to one. In other words, the short-circuit current available to blow this fuse in case of reversal is at least five times the full-load secondary

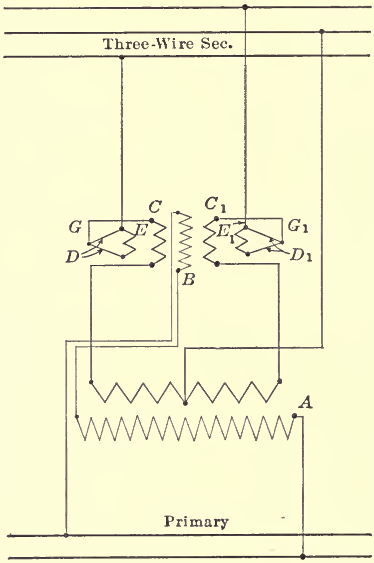


FIG. 1.—PROTECTING SECONDARY NETWORKS AGAINST DEFECTIVE TRANSFORMERS.

current of the transformer. Various tests have been made in the degree of short-circuit in the commercial transformer, varying from a direct short-circuit across its primary terminals to a partial short-circuit on the secondary winding. The protecting fuses D and D_1 blow in every case and almost instantaneously even on the minor short-circuits in the secondary of the transformer. The device operates so effectively that on a few tests a short-circuit in the commercial transformer of such proportions as not to blow the primary fuse did blow the protector fuse. This, however, results very infrequently and was due to the very nice balance of conditions that occurred in some of the tests.

Inserting Spare Transformer in Star-delta Group.—A fourth spare unit is included in the bank of transformers which furnish energy for

the various motors about the new 9000-kw. steam-turbine plant of the Laclede Gas Company, St. Louis. The primary windings of these transformers are connected in star and the secondaries in delta. Switching provision has been made by William Bradford, electrical engineer for the company, so that the spare transformer can be immediately connected in place of any of the other units which may burn out or break down. The scheme used is illustrated in the sketch, Fig. 1. For the star connection three single-pole, double-throw switches are required, while for the delta transfer double-pole, double-throw switches are needed.

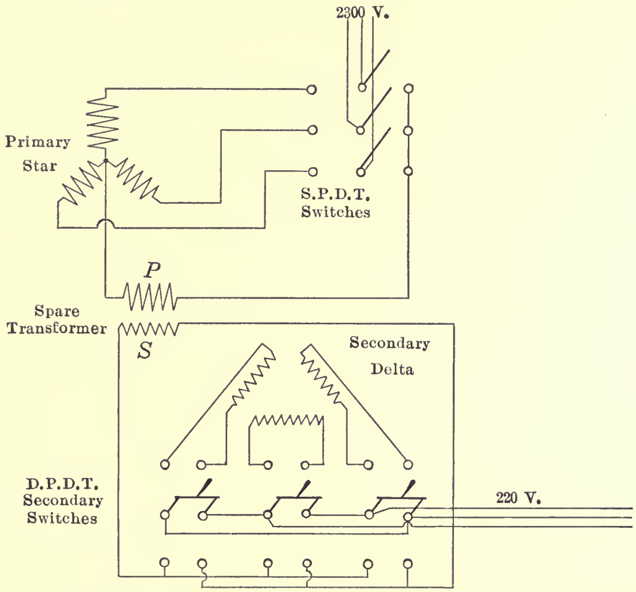


FIG. 1.—INSERTING SPARE TRANSFORMER IN STAR-DELTA GROUP.

The corresponding primary and secondary switches are mounted in line on the board, so that both windings of the spare unit will be automatically connected to the proper phase. The switch panel for effecting this transfer is mounted directly in front of the transformer bank in the basement.

Operation of Tub-transformer Secondaries in Series.—At one of the Omaha company's substations it happened that there was a long and heavily loaded 6.6-amp. inclosed-arc circuit, and near by another similar circuit very much underloaded. From the position of the lines and the streets they served, it would have been inexpedient to transfer lamps from the heavily loaded circuit onto the shorter one. The simplest connection, therefore, seemed that of plugging the two circuits in series at the board and feeding the pair from their 30-kw. constant-

current transformers similarly connected in series. After some misgivings, this was successfully accomplished, and the two tub transformers now pull along together without any signs of trouble. In connecting up these transformers with their primaries in parallel and their secondaries in series it was quickly found that identical polarity arrangements must be preserved throughout. With the two tubs free to regulate separately, objectionable hunting occurred. A slight change in the external circuit would cause unequal compensation in the two units, and then both would oscillate in supplemental fashion, giving poor regulation. This "hunting" was finally avoided by tying the floating-coil

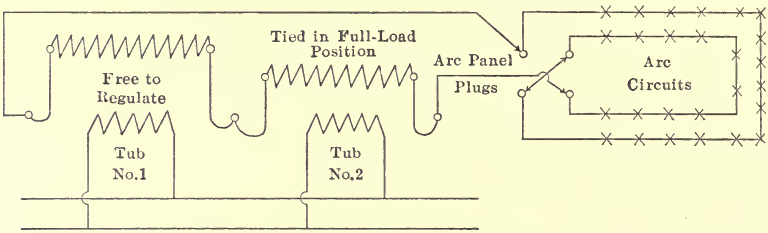


FIG. 1.—OPERATION OF TUB-TRANSFORMER SECONDARIES IN SERIES.

system of one firmly in full-load position, depending on the regulation of the other to control the circuit. A similar scheme has since been applied to the test transformers in the company's lamp-test department, when heavy series loads are to be carried. A wiring diagram of this scheme appears in the upper Fig. 1.

Paralleling Transformer Banks on Star-delta Systems (By R. E. Cunningham).—An interesting condition arises when it is necessary to

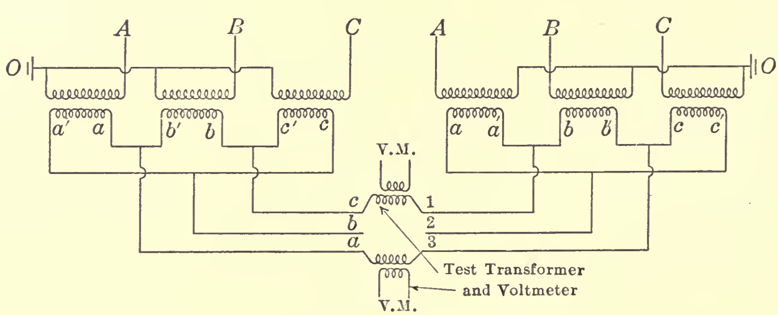


FIG. 1.—PARALLELING TRANSFORMER BANKS ON STAR-DELTA SYSTEMS.

connect in parallel two transformer banks operating on a star-delta system. Assume a case where there is a star-connected transmission system and it is required to install a bank of three transformers to feed into a delta distributing system. Fig. 1 shows the various connections which

may be made, while Fig. 2 shows diagrammatically the two different phase relations produced by these connections.

It will be noted from Fig. 2 that the two different deltas produced will not parallel, regardless of what combination of leads is made. These two deltas are produced by either a "right-hand" or a "left-hand" connection of the primary coils, or by the two possible connections of the secondaries.

Where the transformer banks to be paralleled are of the same type, and it is possible to trace out the connections of both the primaries and the secondaries and make exactly duplicate arrangement of connections, there will be no danger from throwing the two banks together without

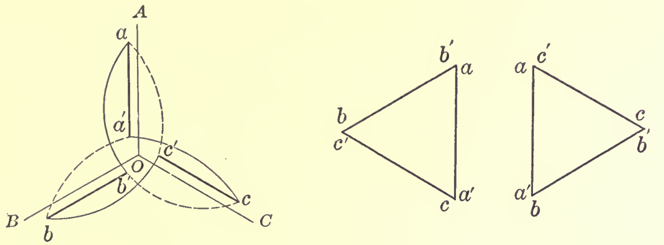


FIG. 2.—PARALLELING TRANSFORMER BANKS ON STAR-DELTA SYSTEMS.

making preliminary tests. But if it is impossible to trace out the connections, on account of the leads being brought out underground, or if it is required to connect in parallel with transformers in a distant substation, a "phasing-out" test must be made. For this test two shunt instrument transformers, of the same voltage as the secondaries of the main transformers, and two voltmeters should be used. For convenience in making this test the three leads of the two lines to be paralleled should be tagged *a*, *b*, *c* and 1, 2, 3 respectively. By testing out the various combinations of leads as shown in the accompanying table, it can be quickly determined whether proper connections have been made for paralleling.

1 2 3 *a b c*	1 2 3 *b c a*	1 2 3 *c a b*
1 2 3 *c b a*	1 2 3 *a c b*	1 2 3 *b a c*

This table shows the six possible combinations, the tests being made by connecting one testing transformer from 1 to *a*, the other from 2 to *b*, or 3 to *c*, etc.

If all of the above combinations are tested out without finding one which gives "no voltage" between the respective leads, it is obvious that the two transformer banks will not parallel, and the connection on one of the banks will have to be reversed according to Fig. 1.

The new connections having been made the series of tests, as shown in the table, should again be made and one of the combinations will be found which will give "no voltage" across the three respective leads.

Two testing transformers are necessary, as there are certain of the combinations of leads which will give double-line voltage, which will cause both voltmeters to show full voltage.

The Three-transformer Method of Changing from Two to Three Phases (By F. T. Wyman).—The method in common use for changing from two phases to three phases, or the reverse, is one involving the use of two transformers with either the secondaries or primaries T-connected. In this method, which is illustrated in Fig. 1, the voltages are subject

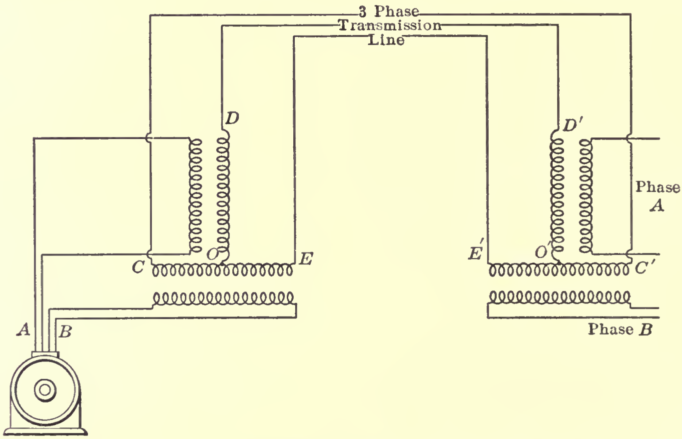


FIG. 1.—TRANSFORMATION WITH TWO TRANSFORMERS.

to distortion not only when secondary loads are unbalanced, but also under balanced non-inductive loads. If one of the transformers becomes inoperative, then only one phase remains active on either the three-phase or the two-phase side, so that the whole system is out of commission until a new transformer can be installed. Consequently, in order to insure continuity of service a spare transformer must be continually carried in stock.

A three-transformer method of obtaining the same results, which seems to possess some merits, although it has not been applied practically to any great extent, is shown in Fig. 2. The transformers are shown Δ-connected on both the primary and secondary sides, although the transmission-line side can be either Δ-connected or Y-connected as the require-

ments of transmission demand, and the neutral of the Y-connected system may be grounded if desired.

In comparison with the two-transformer method, the three-transformer method possesses the advantage of allowing the two-phase voltages to be obtained from the same transformer coils connected for and delivering three-phase voltages; however, the two-phase voltages are not equal in value to the three-phase voltages and the ratio is not a convenient one, being 1.00 to 0.866 = 1.155 to 1.00.

If one of the transformers in the three-transformer system should become inoperative, then the two remaining ones can immediately be temporarily V-connected and carry the load until the other is repaired,

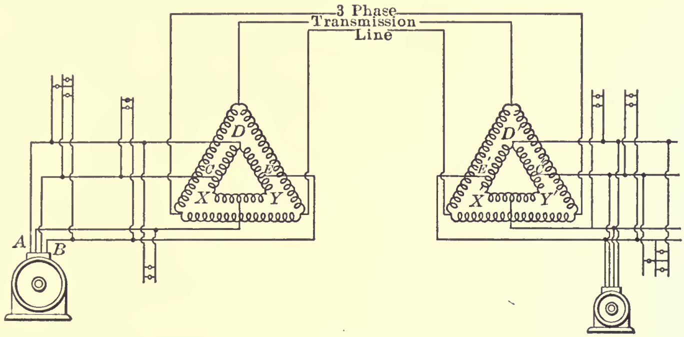


FIG. 2.—TRANSFORMATION WITH THREE TRANSFORMERS.

thus avoiding the necessity of carrying a spare transformer in stock. When a spare transformer is kept in stock its rating is only two-thirds as great as a spare transformer for a two-transformer scheme.

The three-transformer scheme possesses a disadvantage as compared with the two-transformer scheme in that "inter-connected" two-phase generators or motors cannot be used, as destructive local currents would be produced in the windings. It is superior to the two-transformer scheme in its greater freedom from unbalancing of voltage and larger factor of safety for continuity of service.

Low-freezing Mixtures for Oil Switches (By F. W. Harris).—It is common for oil switches to be so located that they are exposed to extreme cold. The effect on the ordinary transformer or switch oil is first to render it very thick and at very low temperatures actually to solidify it. Even if it is reduced to the consistency of a thick jelly it is likely to interfere seriously with switch operation, and it is desirable in switches so exposed to provide a liquid that is not open to this objection. There are now on the market several oils that have very low freezing points. In this connection it is desirable to point out that were it not for two features tetrachloride of carbon would be far superior to any oil for use in

such switches. It is not inflammable and does not produce inflammable vapors and it has a very low freezing point. It is, however, rather expensive, about seven times as expensive as a good oil, and it is volatile, producing disagreeable vapors at a relatively low temperature. It is probable that if the matter of price could be corrected it would come into very general use for this purpose, special switches being arranged for it. It is valuable for reducing the freezing point of oil, and a half-and-half mixture will not stiffen up appreciably at 20 deg. below zero C. It must however be watched as it evaporates and its use is not to be commended at this time.

Turpentine, however, may be used with good effect. A half-and-half mixture of good turpentine and ordinary transformer oil will freeze at about −30 deg. C. It does not materially lower the breakdown voltage and is not harmful owing to carbonization in breaking the circuit. It is inflammable and evaporates, but the standard low-freezing mixtures and oils also do that. It used to be the practice to use on the outdoor switches of the New York, New Haven & Hartford Railroad a low-freezing oil in the winter and to take it out in the spring and use standard oil in the summer. When operators have trouble with switches freezing this turpentine mixture is a good one to know about, and if a little care is used no harmful results need be feared. It is probably too volatile for summer use, however, and should be removed in the spring before the warm days come.

Disconnect Coupling for Oil-switch Leads.—In the installation of oil switches, lack of space or other conditions sometimes make it impossible to locate disconnect switches between the oil switch and bus, where the

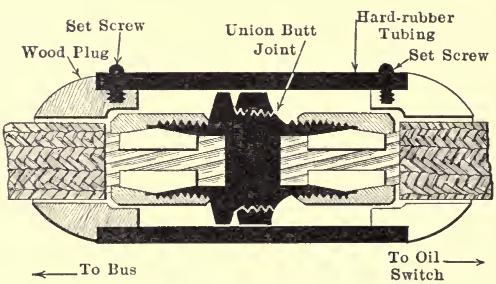
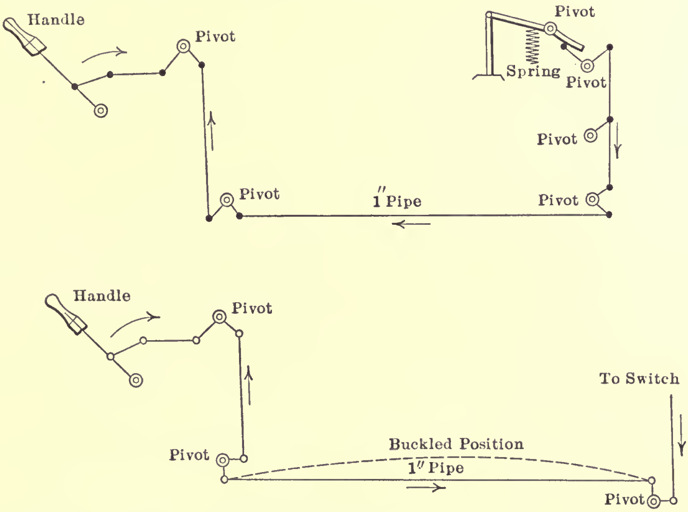


FIG. 1.—DISCONNECT COUPLING FOR OIL SWITCH LEADS.

use of such switches would be advisable to render the oil switch "dead" for adjustment or repairs. This condition existed in the 2300-volt station of the Anaconda Mining Company at Butte, Mont., where the 300-amp. oil switches were installed with terminals connected directly through vertical leads to the buses. To take the place of disconnect knife switches and make possible repairs on the apparatus, Mr. W. S. Guthrie.

chief electrician, designed the insulated joint feature Fig. 1, page 168, the special fittings being made on order by the manufacturer of the solderless fittings used. In place of the usual solid hexagon nut employed on ordinary Dossert couplings, the fitting is broken into two parts held together by a union nut coupling, which makes a firm butt contact between the 1-in. flat bearing surfaces. This nut can be unscrewed with an insulated-handle wrench, opening the line and disconnecting the device. The connector parts are protected against short-circuit or accidental contact by the hard-rubber covering shown. After investigating the cost of special hard-rubber castings for the purpose and finding the expense of these such as to make them out of the question, Mr. Guthrie was able to utilize stock rubber tubing 1.75 in. in diameter, cut into 6-in. lengths. These tube sections are held in position by the filled-wood cap pieces, which are in turn fixed in place by small set-screws. To gain access to the connector it is necessary merely to remove the upper screw, allowing the tube section to drop down out of the way so that the hexagon nut can be gripped with the insulated wrench.



FIGS. 1 AND 2.—CORRECT AND INCORRECT ARRANGEMENT OF SWITCH PULL-RODS.

Switch Pull-rods in Tension, Not Compression.—The oil switches in a certain substation had given trouble ever since the time of their erection. They were operated by long rod-and-lever connections as shown in Figs. 1 and 2, and the switches controlled a 25,000-vol three-phase line. The difficulty seemed to be that the operators continually broke down the castings of the mechanism, effecting automatic release from the handle. Complaint was made, too, that the switches were hard to open and close.

After investigation it was found that the levers and pull-rods had been wrongly connected, the arrangement being such as shown in Fig. 2, which placed the long 1-in. pipe in compression when the switches were being closed. This caused that part to sag, jamming and blocking the mechanism. The rods were then overhauled and converted to the arrangement shown in Fig. 1, a spring being added, thus putting the parts in tension during operation. Since this change was made the switches have worked easily and without further trouble.

Troubles Due to Non-use of Circuit-breakers (By F. W. Harris).—A common source of complaint is the heating of the contacts of carbon circuit-breakers after they have been in service for a long period. These breakers usually have a laminated brush made up of thin leaves of copper, and any temperature over a certain very well-defined maximum will result in the brush becoming soft and losing its elasticity. Therefore the heating becomes very much worse, rapidly resulting in the ruin of the brush and sometimes a shut-down of the plant. Troubles of this kind are commonly attributed to the design of the circuit-breaker itself, but a great deal is due to conditions against which no modifications of the design could be expected to guard.

Heating of contacts is very noticeable in steel mills, and one case of long-continued trouble resulted in dismantling the circuit-breakers on three successive July Fourths, this being the most convenient day to the mill superintendent. The instruments were rated at 10,000 amp. and ran on a load much below this. After they were put in first-class condition they ran quite cool for some months, the heating gradually increasing until they had to be overhauled again. An examination showed that the troublesome circuit-breakers were connected on a circuit that was never opened except upon dead-short-circuit conditions, and that these conditions did not obtain more than once or twice a year.

The trouble was traced to a gradual oxidation of the contacts and to the fact that the troublesome circuit-breakers were never opened and closed to rub off the oxide. It was found that if the instruments were opened and closed a few times on Sunday it was possible to keep the contacts bright. The other circuit-breakers in the plant were naturally satisfactory, as they opened many times a day and that kept the contacts clean.

In general, where open air-type switches are not operated frequently it is an excellent plan to clean them with emery cloth at least once a month, and where the contacts are not easily accessible, as in this case, they should be opened and closed vigorously say a dozen times once a week.

Temporary Repair to Oil Switch.—The accompanying Fig. 1, shows the temporary repair made on a circuit-breaker operating handle which

had broken down at the catch notches designed to hold the handle in the closed position. Side blocks were accordingly made the same shape as the notch parts, using flat pieces of iron. These side pieces were then fixed in place by the cotter pins which hold the tripping roller inside. The job cost little to carry out, and will keep the oil switch in operation until a new casting can be secured.

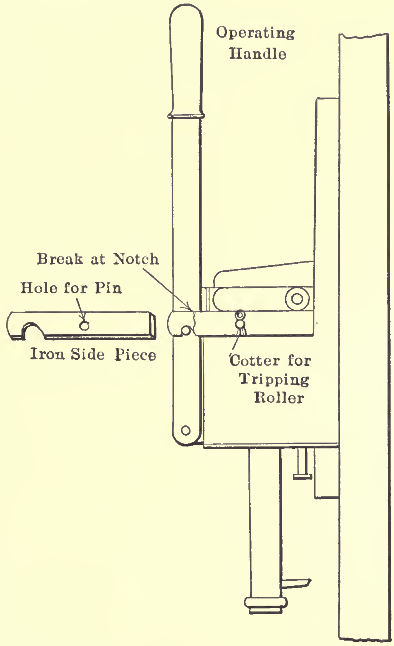


FIG. 1.—TEMPORARY REPAIR TO OIL SWITCH.

Alarm Connection for Transformers.—In the upper Fig. 1, page 172, alarm circuits are shown for detecting abnormal rise in temperature, failure of cooling-water supply or lowering of oil level, in cases where station transformers are installed at points remote from frequent inspection by the switchboard operator. By the arrangement illustrated the operator can test his oil, water and temperature without leaving his position. The water alarm is provided by a compression element inserted in the inlet line so that as long as pressure is on the piping the contact is open. If pressure fails for any reason, the circuit is completed, ringing the alarm bell and lighting an indicator lamp. A generally similar oil-level float alarm is installed at the top of the transformer tank to give warning of lowering of the oil. Here also is placed a thermometer with an electrical contact inserted at the point of maximum allowable temperature rise. If the transformer becomes overheated the thermometer circuit will be completed, also giving an alarm. The

switchboard circuits may be arranged to give visible and audible warning automatically, or the attendant may be required to make regular inspections and tests.

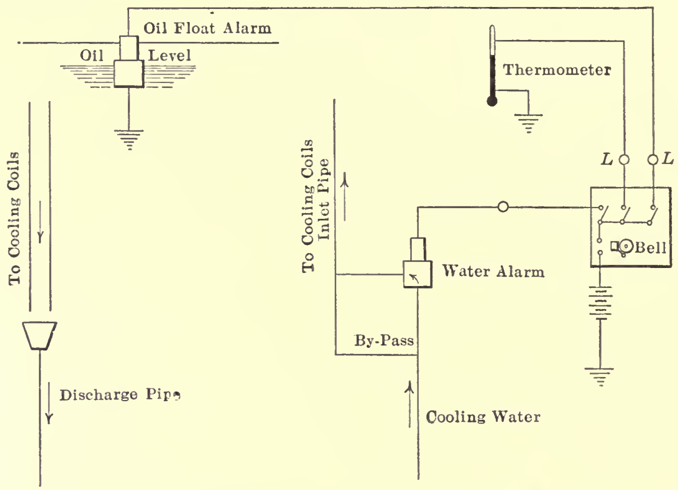
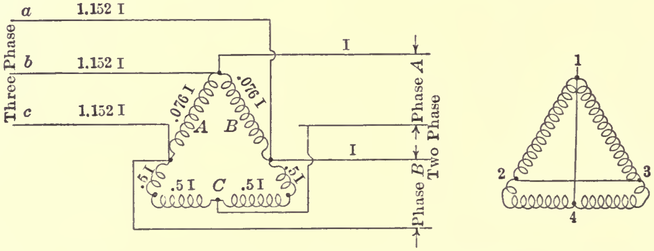


FIG. 1.—ALARM CONNECTION FOR TRANSFORMERS.

Two-phase to Three-phase Auto-transformers (By Roy E. Uptegraff). —Occasionally it is desired to transform from two-phase to three-phase or three-phase to two-phase, as the case may be, to run a three-phase motor or other apparatus from a two-phase line, or *vice versa*. This may be accomplished by placing on each leg of a three-phase core single windings as shown in Fig. 1. Each leg is wound with sufficient turns for 115.2



FIGS. 1 AND 2.—TWO-PHASE TO THREE-PHASE AUTO-TRANSFORMERS.

per cent. of the line voltage, and taps are brought out for 100 per cent. and 50 per cent. of the line voltage as shown.

For a better understanding of the two-phase and three-phase relation, reference should be made to Fig. 2. Lines 1 and 4 and 2 and 3 in the figure represent vectorally the two phases of the two-phase circuit since they are equal in length and at right angles to each other, the two-phase angle being 90 deg. Lines 1 and 2, 2 and 3 and 3 and 1 are equal and are

at the angle of 60 deg. with each other, this being the three-phase delta angle.

If the current in the two-phase side be represented by I, the current in the three-phase lines will be 1.152 I, neglecting the magnetizing and loss currents. The currents in the three legs of the delta are not equal but are as shown in Fig. 1.

The winding in legs A and B required for 100 per cent. of the voltage need be large enough for only 7.6 per cent. of the two-phase current, while the extra 15.2 per cent. of the winding must be designed for 50 per cent. of the two-phase current. The current in leg C must be designed for 50 per cent. of the line current.

In explanation of the different currents in the windings it will be noted first that in Fig. 1 the apex of the delta is connected to one three-phase line and one two-phase line. Since the currents in the three-phase lines are equal to 1.152 I and the two-phase current is I, then the current in the upper parts of sides A and B of the delta is $1.152\ I-I=0.152\ I$, or 0.076 I in A and B each from the apex to the tap. The rest of the sides A and B must be designed for the same current as in side C, as these are connected in series.

As the whole two-phase current flows into the middle of side C as shown, it can be easily seen that 50 per cent. of this current will flow in each half and the lower parts of sides A and B.

The size of standard three-phase transformer parts required for a two-phase-three-phase auto-transformer of this type is found as follows:

The value of the kilovolt-amperes in the sides A and B is $2(0.076\ I \times E+0.5\ I\times 0.152\ E)\ 10^{-3}=0.304\ I\ E\times 10^{-3}$.

The kv.-a. in side C =

$$0.5\ I\times 1.152\ E\times 10^{-3}=0.576\ I\ E\times 10^{-3}.$$

The total kv.-a. in the windings =

$$0.304\ I\ E\times 10^{-3}+0.576\ I\ E\times 10^{-3}=0.88\ I\ E\times 10^{-3}.$$

As this amount of power is transmitted through only one winding on each leg, while an ordinary two-coil transformer would have two windings on each leg, for this amount of power, in terms of an ordinary transformer,

the rating would be equal to $\frac{0.88\ I\ E\times 10^{-3}}{2}=0.44\ I\ E\ \times\ 10^{-3}$ in kv.-a.

The power in the line is $2\ I\ E\ \times\ 10^{-3}$. Therefore, the rating of the auto-transformer in terms of a standard transformer as a percentage of the line kv.-a. may be expressed as $\frac{0.044\ I\ E}{2\ I\ E\times 10^{-3}}=22$ per cent.

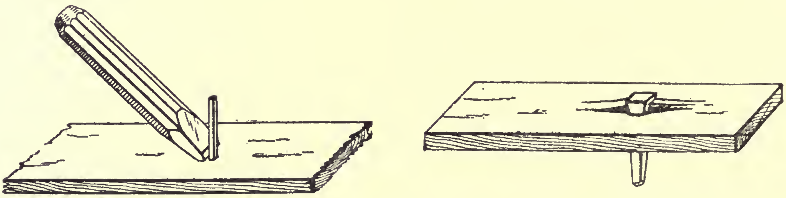
The most desirable feature of the above auto-transformer over that of other methods for two-phase to three-phase transformation, according to the author's point of view, is its balanced operating condition. This method of transformation was devised by William T. Taylor.

IX

INTERIOR WIRING

Methods of Wiring Buildings of Different Construction and Under Various Atmospheric Conditions, Descriptions of Special Devices and Equipments

Removing Nails from Trim in Old-house Wiring (By George M. Talbot).—Before replacing finished trim that has been removed to permit the running of wires the nails in the trim should be cut off flush with the back of the trim with a pair of pliers or a cold chisel (Fig. 1), or should be broken off with a hammer. If an attempt is made to drive them out, they will almost invariably chip out slivers of the trim, as



FIGS. 1 AND 2.—REMOVING NAILS FROM TRIM IN OLD-HOUSE WIRING.

indicated in Fig. 2. New finishing nails of small diameter should be used for refastening the trim.

Examining Partition Interiors (By Wm. Sprunt).—A pocket flash-lamp and a little mirror are the only apparatus required to inspect the

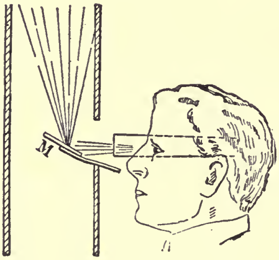


FIG. 1.—EXAMINING PARTITION INTERIORS.

interior of a wall or partition which would ordinarily be inaccessible. For fishing wires, retrieving cable and inspecting finished work, this use of the lamp and mirror provides a labor-saving "kink." The mirror has only to be introduced in the outlet hole in the wall, the

flashlamp and eye being held behind it, Fig 1, page 174. The mirror reflects the light of the lamp onto the place to be illuminated, at the same time reflecting the image back to the eye near the lamp. The usefulness of this little device is as great as its simplicity.

Grounding of Bathroom Fixtures, Etc.—All fixtures installed over or near damp grounds, earth floors, metal steps, radiators, bathtubs, washbasins, etc., are now required by the Omaha city electrical inspection department to be securely grounded. City Electrician Michaelsen also recommends generally that porcelain receptacles be used in these places

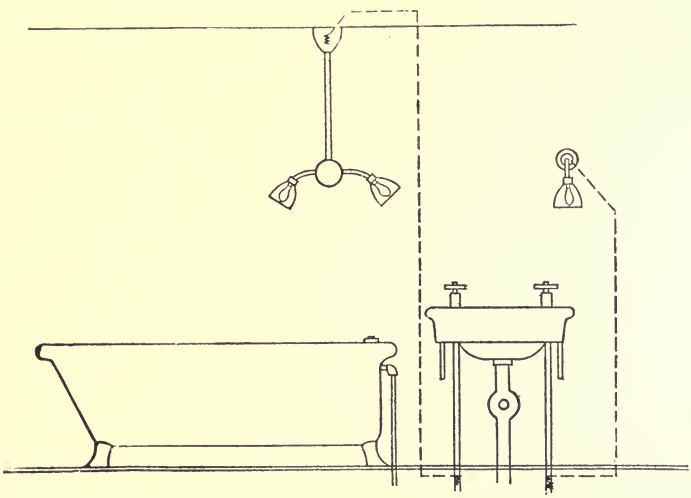


FIG. I.—GROUNDING OF BATHROOM FIXTURES.

unless such sockets detract seriously from the appearance of the installation, in which case the porcelain proviso is waived. As a protection against any part of bathroom fixtures becoming charged this grounding ordinance is now being rigidly enforced in Omaha wherever fixtures, sockets, etc., are near enough to be reached or touched while making contact with grounded conductors. (See Fig. 1.)

Support of Cables for Interior Work.—It frequently happens that cables have to be supported beneath ceilings having arched construction, and supports at the drop beams are too far apart to keep the cable from sagging considerably. A simple device is used by the Freeman-Sweet Company, Chicago, to avoid this difficulty. As shown in the accompanying view, Fig. 1), the cable is supported at the drop beams in the ordinary manner. Between the drop beams and beneath the crest of the arch a cable clamp is secured to the cable and also to a toggle-bolt which may be shoved through a small hole in the arch above. The toggle-bolt is of the collapsible type, and all that is necessary to install

it is to drill a hole just large enough to allow the head of the toggle to slip through, the bolt being moved around until the toggle opens. This method has been found satisfactory both as to ease of installation and as to the result obtained.

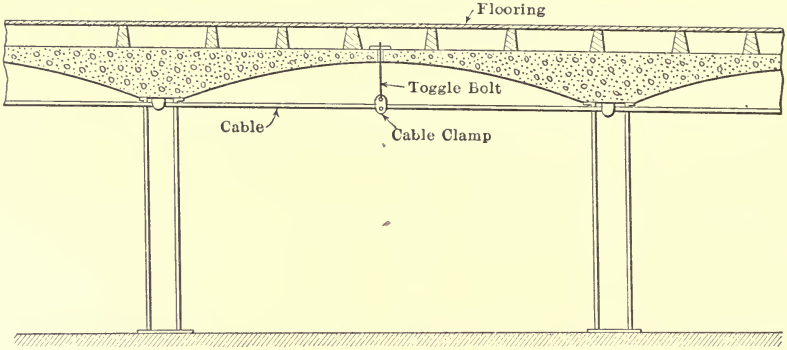


FIG. 1.—SUPPORT OF CABLES FOR INTERIOR WORK.

Explosion-proof Connector Plug.—In garages and other places containing explosive gases a great deal of risk accompanies attempts to use ordinary insertion plugs for making temporary connections. A

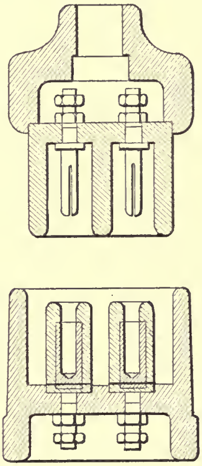
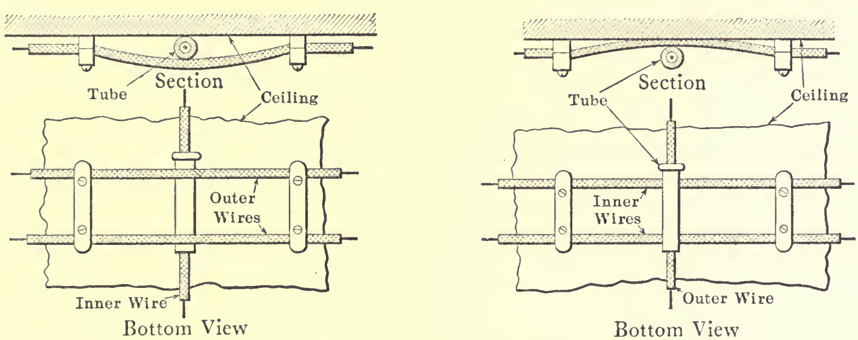


FIG. 1.—EXPLOSION-PROOF CONNECTOR PLUG.

German concern which owns a number of garages has made experiments to obtain a reliable explosion-proof plug. The one shown in Fig. 1 was designed by one of its engineers and has been submitted to exhaustive tests at the Royal Testing Laboratories at Gross-Lichterfelde, Germany, and is said to have proved very satisfactory. It will be seen that in making the contact the pins are inserted into shells of insulating material sur-

rounding the metal part of the receiver. These shells fit snugly about the contact pins so that when the connection takes place the surrounding air is excluded. As a further precaution there is an outer shell around the contact pins which fits into an outer shell of the receiver. This excludes the air even before the pins reach the inner shells.

The Right Way to Place Protecting Tubes (By G. Converse).—A tube for protecting a wire where it crosses another wire should always be so placed that the tube will not force the unprotected wire against the surface supporting the conductors. The tube should always be on the inner wire. If placed on the outer wire the tube may force the unprotected wire against the surface as shown in Fig. 2. Oftentimes



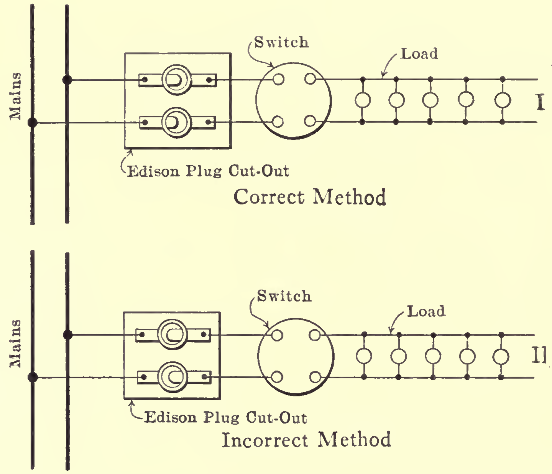
FIGS. 1 AND 2.—CORRECT AND INCORRECT METHODS OF PLACING TUBE.

porcelain tubes are used on wires crossing each other in boiler-rooms or locations having steam pipes. It is readily seen that if the porcelain tube is placed on the lower instead of on the upper wire it would force the upper wire against the hot pipe, with the result that the insulation would be quickly destroyed and a ground or short-circuit ensue.

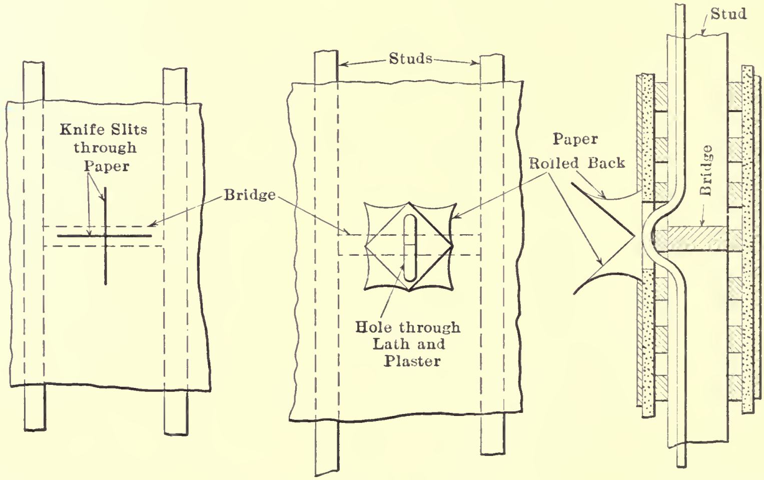
Right and Wrong Methods of Connecting Plug Cut-outs (By H. M. Sanders).—In connecting Edison plug cut-outs they should always be so arranged that the screw shells, which extend beyond the porcelain, will not be alive normally. The upper Figs. 1 and 2 on page 178 show the right and wrong methods respectively. If connected incorrectly, there is constant danger of short-circuit or shock when men are working about the cut-outs with bare wire ends or tools. Some types of plug cut-outs are so constructed that the porcelain is higher than the screw shell, which is thereby protected. Such cut-outs would be properly connected as shown in either I or II, and they should be selected where possible.

A Method of Carrying Wires Around Bridges in Old Houses (By J. G. Johns).—In wiring old buildings one of the most troublesome tasks is to run vertical conductors within a partition space between studs where the normal course of the conductors is blocked by a bridge. If the space

between studs is adjacent to a doorway, the conductors can be carried around the bridge by removing the jamb. If a doorway is not adjacent and the bridge cannot be bored through from above with a long boring tool, because of obstructions, it is necessary to cut into the surface of the wall.



FIGS. 1 AND 2.—RIGHT AND WRONG METHODS OF CONNECTING PLUG CUT-OUTS.



FIGS. 1 AND 2.—METHOD OF CARRYING WIRES AROUND BRIDGES IN OLD HOUSES.

With certain kinds of wall paper the method that is here described can be used with practically no visible damage. If moisture will disfigure the wall paper, however, the method cannot be used. Cartridge papers are, as a rule, not affected by a little water. In order to ascertain

the effect of water on the paper in question, it will be necessary to experiment with a small area in an inconspicuous corner if a sample of the paper cannot be had.

If the paper stands the test, two slits should be cut through it at right angles to each other, see lower Fig. 1, page 178, at a point just opposite the bridge that is in the way. The bridge can be located by dropping a "mouse" on it from the outlet hole cut through the partition at a point above it. A sharp knife is necessary in cutting the slits.

The paper should then be soaked slightly around the slits with a wet sponge or cloth. When the water has been absorbed by the paper and the paste that held it to the wall has softened, peel back the four triangular sections of paper. When the paper is completely "peeled" it will appear as shown in Fig. 2. Through the bared plaster cut holes into the partition above and below the bridge, and remove enough plaster from in front of the bridge to leave a cavity that will accommodate the loom-covered conductors. The conductors may then be run in as suggested in the longitudinal section in Fig. 2. The holes left in the wall surface should be filled with plaster of paris and the paper carefully replaced with the aid of a flour paste. If the job is neatly done it will be difficult to find where the paper was cut. In peeling the paper from the wall a wide-bladed putty knife will be found a very convenient tool.

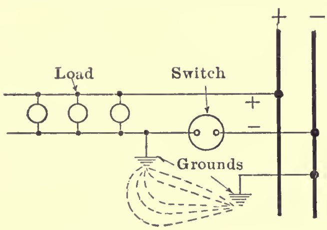


FIG. 1.

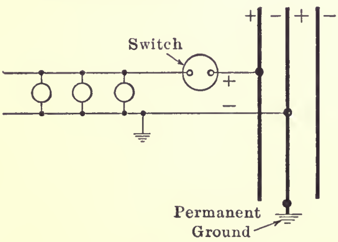


FIG. 2.

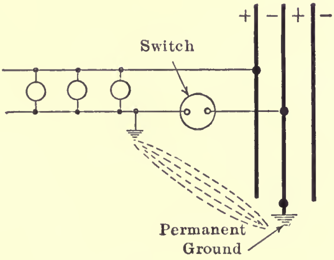


FIG. 3.

FIGS. 1, 2 AND 3.—THE USE OF SINGLE-POLE SWITCHES.

The Use of Single-pole Switches (By H. G. Clark).—Single-pole switches are permitted by the Underwriters on circuits carrying loads not exceeding 660 watts at pressures not exceeding 250 volts. This

gives a maximum permissible current of 3 amp. at 220 volts or 6 amp. at 110 volts. With these loads, single-pole switches will give good service in residences where the circuits are not apt to be disturbed, but in industrial plants, single-pole switches may not protect from trouble, and it is good practice to use double-pole switches in installations where reliability in service is important. Single-pole switches may not protect from trouble because they open but one side of the circuit. In Fig. 1, page 179, if one side of a two-wire main happens to be grounded, a ground of the same polarity on a branch circuit controlled by the single-pole switch will form a closed circuit around the switch. If the grounds are of sufficiently low resistance, enough current will flow to light the lamps, even with the switch open. If the resistance of the grounds is high, not enough current will flow to light the lamps. Furthermore, with conditions as shown in Fig. 1, if a wireman accidentally touches a wire of the positive side of the branch circuit to any grounded object, such as a gas pipe, a short-circuit will result. Single-pole switches in two-wire branches from three-wire mains should not be inserted in the branch wire connected to the neutral wire of a three-wire system (Figs. 2 and 3). The neutral of a three-wire system is usually permanently grounded at the central station as well as elsewhere, and with the switches in a neutral branch wire (Fig. 3), trouble is more apt to occur than when the switch is in the other branch wire, as at Fig. 2.

One-piece Versus Two-piece Push Switches (By Eugene E. Smith).—In electrical installations careful study should be made of all points in connection with the materials used and their maintenance. In this connection the flush push-switch problem is often overlooked, and the cheapest article is often selected, with bad results. The field of push switches is wide, and prices and results vary. The switches are divided into two general groups, the one-piece and the two-piece switch; by this is meant one in which the mechanism is permanently fastened to its shell and one in which there is a detachable mechanism. The one-piece switch has been in existence since the beginning of electrical control, and has been improved upon from time to time, until improvement had to take a long jump and the detachable-mechanism switch was evolved, with many points in its favor. Granted that the action of one mechanism is as good as the other under conditions that are ideal but which seldom obtain, the danger of damage in the case of the one-piece switch is often detrimental to the proper action of the mechanism. A favorable point to the credit of the one-piece switch is its first cost. The cost to install each switch is equal, but the mechanism of the one-piece switch is liable to injury from all sources, while in the two-piece switch the shell can be installed independently of the mechanism; that is, the wires can be permanently connected and a protecting sheet placed in

the shell. The mechanism is thus not liable to damage by plaster, paint, water, etc., present in both new and old buildings. These points are very often overlooked, while they are very important to switch maintenance. Complaints are very often lodged against a non-operating switch, and in most cases defective operation is due to damage caused by plaster getting in the mechanism, or paint causing the push points to stick, or water or dampness causing the mechanism to rust. These defects are likely to present themselves in the one-piece switch, because of the necessity of installing the switch before work is finished in the building, so as to complete the electrical contract on time. The use of the two-piece detachable-mechanism switch avoids all this trouble, because of the installation of the shell only, thus saving the mechanism from possible damage by the causes given. The installation of the mechanism calls for so little additional labor that no account need be taken of it. The replacing of a switch mechanism that has given out by hard usage is a big item to be considered when making the initial installation. This may seem a consideration that is a great distance off, but no one can judge the actual operation of any movable mechanism, as can be seen by the guarantees that are given, which seldom run over two years. The installation of a push switch is often made with the idea that it will last as long as the building; but that is poor judgment, and the question of replacement should be taken seriously. The replacement of the one-piece switch means labor and cost equal to the first installation; that is, purchasing a complete mechanism and shell, disconnecting wires and switch and reconnecting wires and switch, with the possible breaking of wires from bending and handling, thereby shortening them and requiring a new circuit or tap, which means added labor and expense. The replacement of a two-piece switch means the removal of the plate, the pulling out of the defective mechanism, the insertion of the new mechanism and the replacement of the plate, all of which is done in less time than it takes to write about it. The cost for replacement is in favor of the two-piece, detachable-mechanism switch. In making replacements damage done to the surrounding walls has to be considered, if it is done in a place where looks count for something, as in a hotel, residence, public hall, school, office, etc. The detachable-mechanism switch, which requires little labor and that of a clean nature, thus scores a point. Another point that may not be serious, but is worthy of consideration, is the element of time when a replacement is to be made, say, in a guest's room in a hotel. Nothing need be said regarding which switch is more advantageous under these conditions. The installation of a one-piece switch under similar conditions would mean that the electrician would have to take tools, an extension lamp cord and a one-piece switch. Arriving at the room, he would have to disconnect the defect-

ive switch and reconnect the new switch, always taking the precaution not to soil the walls. There are a number of instances that could be cited to the credit of the two-piece detachable-mechanism switch.

An Electric Iron Installation (By George Travert).—A method of supporting the conducting cord of an electrically heated iron is shown in Fig. 1. The feature of the arrangement that deserves attention is the sliding support for the helical spring that carries the cord. The ordinary method of supporting the cord of an electric iron is to tie it to a spring which is attached in a permanent position and the fact that the location of the spring is fixed hampers the movements of an operator using the iron. With the scheme suggested in Fig. 1 the spring is fastened with an "S" hook (see Fig. 2) to a porcelain insulator which

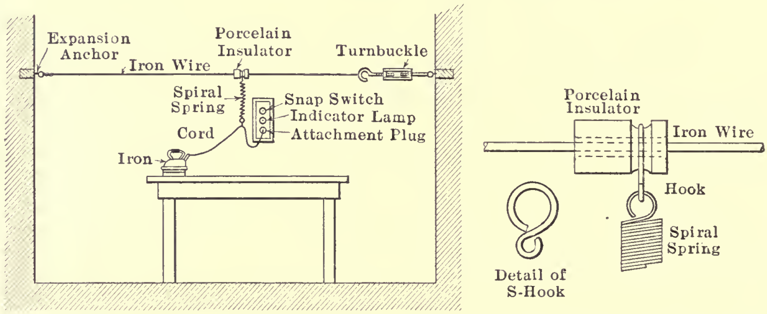


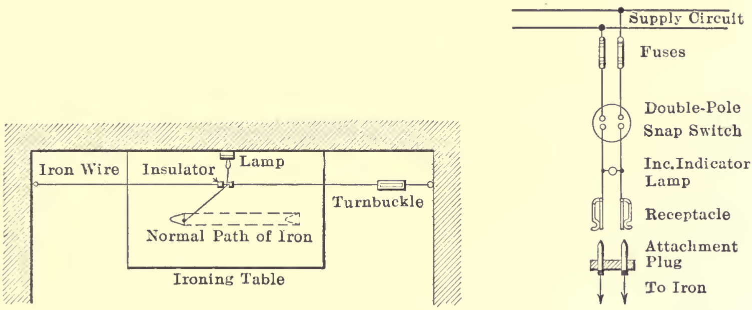
FIG. 1 AND 2.—AN ELECTRIC IRON INSTALLATION AND METHOD OF SUPPORTING SPRING.

is arranged to slide back and forth on a wire. As the iron is pushed to and fro the porcelain insulator follows its movements and, as the spring will stretch, ironing can be done over a considerable area. It should be noted that at all times the conducting cord is supported well out of the way of the operator.

Spiral springs, like that illustrated in Figs. 1 and 2, are usually furnished by the manufacturers with all sadirons, so that the only additional material that is needed to make such an installation is the insulator, the iron wire and the turnbuckle. The iron wire, Fig. 1, is made up in a screw-eye, inserted in the wall at one end and into one eye of a small turnbuckle at the other end. Such a turnbuckle can be supplied by any first-class hardware house. The turnbuckle provides means for keeping the wire tight. The hook end of the turnbuckle engages with a screw eye inserted in the wall. It is well to arrange the iron wire somewhat to the rear of the line along which the iron will be used, as shown in Fig. 3. This is done to prevent the cord from striking the hand of the ironer.

A convenient method of wiring an electric iron is shown in Figs. 1

and 4. The visible components of the circuit are shown in Fig. 1 and the wiring diagram is given in Fig. 4. An incandescent lamp of small candle-power is connected across the branch circuit to the iron on the iron side of the double-pole switch. So long as the switch is closed and the iron connected to the supply source the lamp will glow and indicate the fact that the iron is "alive." This device not only tends to make the operator careful in his use of energy, but it assists in preventing



FIGS. 3 AND 4.—PLAN VIEW OF INSTALLATION AND WIRING DIAGRAM.

the fires that are sometimes caused by an electric iron being left on a wooden ironing board while connected to a supply source.

Wiring Buildings with Cinder-filled Floors (By George Hartley).—Occasionally in wiring old buildings a wireman will encounter a floor partly filled with cinders between the joists. Floors are seldom built in this way now, but fifteen or twenty years ago the construction was common in the better class of residences and business buildings. In

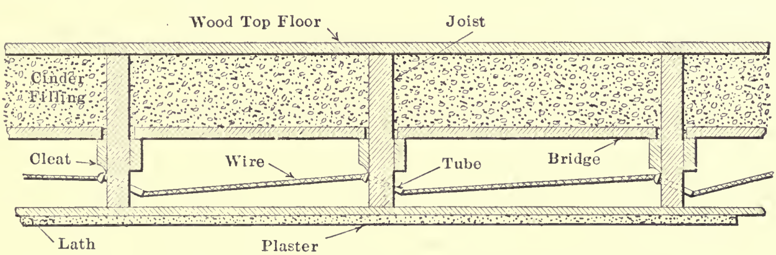


FIG. 1.—WIRE INSTALLED BENEATH CINDER-FILLED FLOORS.

running circuits beneath such a floor the wireman can take out some of the cinders after removing the floor boards parallel to the run. Only enough cinders should be taken out between each pair of joists to expose a complete "bridge" board so that it can be pried out. The bridge board out of the way, the holes for the tubes, or for flexible conduit if such is used, are bored below the cleats with a long bit. The latter

type is necessary because one of ordinary length cannot be used, owing to insufficient working room. If a long bit is not at hand, one can be made by having a blacksmith weld a shank of the necessary length, possibly 30 in., to an ordinary carpenter's bit. Fig. 2 illustrates the conditions that prevail while the joists are being bored. After the procelain tubes have been inserted and the wire threaded through them, or after the flexible conduit has been run through the holes, the bridge pieces may be nailed in place. The cinders may then be scraped back and the top floor boards relaid. Fig. 1 on page 180 illustrates a sectional view of a finished job.

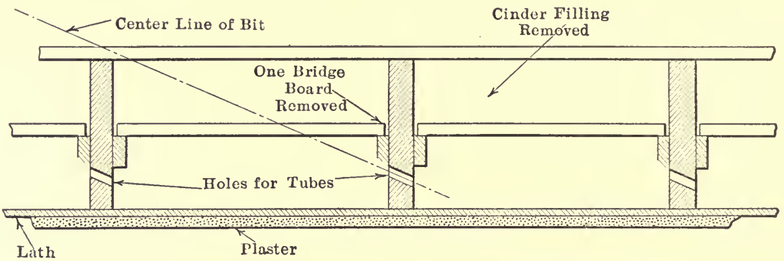


FIG. 2.—BORING HOLES THROUGH JOISTS.

Home-made Chandelier Hooks and Loops (By E. B. Watson).—Chandelier loops and hooks are often used in connection with conduit wiring installations. Applications are shown in Figs. 1 and 2 on page 182. Fig. 1 represents an arc lamp suspended at the middle of a bay, in a building of wooden mill construction, by a chandelier loop and hook. From the loop a chain is carried to the roof above and secured in a screw-eye turning into the roof timbers. Through this arrangement the stress, due to the weight of the lamp, is taken almost wholly by the chain and there is practically no tendency for the conduit to break, in the threads, where it turns into the conduit tee. If a chain or some auxiliary support is not used 1/2-in. conduit will not support, without excessive deflection, an arc lamp at the center of a 20-ft. bay. The lamp hangs on a chandelier hook turned into the bottom outlet of the conduit.

Fig. 2 illustrates a method, often utilized, for supporting a tungsten lamp fixture at some point between trusses. The example is taken from an installation in a steel factory building. The main conduit is clamped, with U-bolts, against the upper edges of the two angles forming the bottom chords of the roof trusses. Two chains are necessary here. Each chain is made fast, at its upper end, to one of the truss members near the roof. It would not be practicable to use only one vertical chain, because the roof is a concrete slab to which attachment would be difficult. It is cheaper and better to use two chains than to drill and plug the concrete roof in order to effect an attachment.

In both of the cases cited (Figs. 1 and 2) the chandelier loop is of the ordinary commercial pattern, which can usually be obtained at any plumbing or electrical supply house. It will be usually cheaper to buy chandelier loops and hooks ready made than to make them. If it is not practicable to buy them, or if some are needed immediately and there is not enough time to send to the dealer, they may be made as suggested in Figs. 3 and 4.

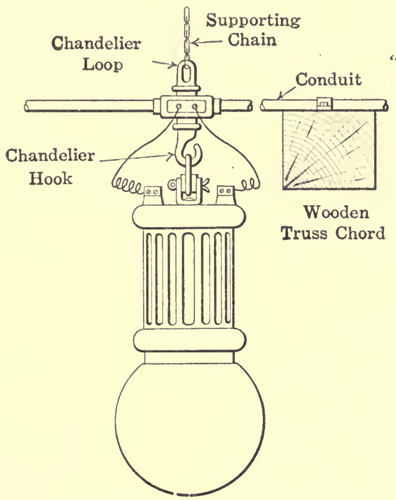


FIG. 1.—CHANDELIER LOOP AND HOOK SUPPORTING ARC LAMPS.

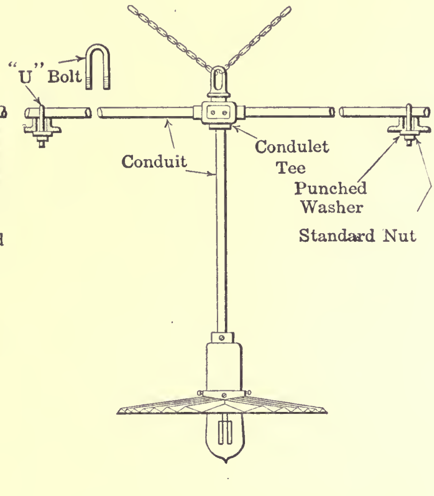


FIG. 2.—TUNGSTEN FIXTURE SUPPORTED BY CHANDELIER LOOP.

In the method shown in Fig. 3, an ordinary commercial pipe cap is drilled and tapped, and a piece of wrought-iron rod, say of a diameter of 1/4 in. is threaded on one end and has a ring formed at its other end. Whether the ring is left open or closed depends on whether the resulting appliance is to be a loop or a hook. The threaded end of the loop or hook

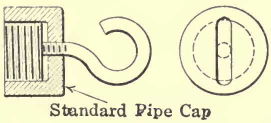


FIG. 3.—CHANDELIER LOOP MADE FROM PIPE CAP.

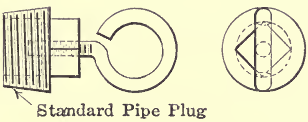


FIG. 4.—CHANDELIER LOOP MADE FROM PIPE PLUG.

is turned into the hole tapped in the cap and the device is complete. To prevent any possibility of the loop turning out of the hole it is a good plan to "bead-over" its end on the inside of the pipe cap. The wrought-iron rod shown in Fig. 3 is so bent as to form a hook rather than a loop.

A "home-made" loop is illustrated in Fig. 4. In this, a pipe plug, a

readily obtainable fitting, is drilled and tapped to receive the threaded end of the loop. The construction outlined in Fig. 3 is neater than that of Fig. 4, but usually either is installed where it cannot be seen, so appearance is of little consequence. The plug loop (Fig. 4) can be turned directly into a conduit fitting while an additional nipple is required where the cap loop (Fig. 3) is used. Because of this the plug construction is usually preferred.

Simplifying Concealed Conduit Work (By T. W. Poppe).—It seems strange that after several years' use of rigid conduit in a progressive and inventive country the bending of conduit for concealed work is still adhered to. Special fittings are manufactured which greatly simplify the

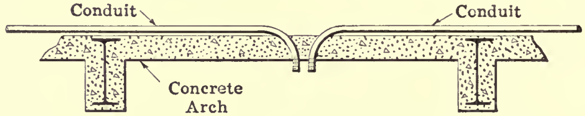


FIG. 1.—CORRECT INSTALLATION OF BENT CONDUIT.

installation of exposed conduit. But no genius has turned his talent toward simplifying the installation of concealed conduit. No doubt a great saving of time would be affected if a fitting could be manufactured to obviate the necessity of bending the several conduits which go through the concrete floor to the lamp outlet on the ceiling below.

For example, when installing conduit in a fireproof building where the arches or bays are made of concrete, the plan now followed is to run the conduit from outlet to outlet while the concrete mixture is still soft. This means that one conduit must enter the outlet and one must leave it.

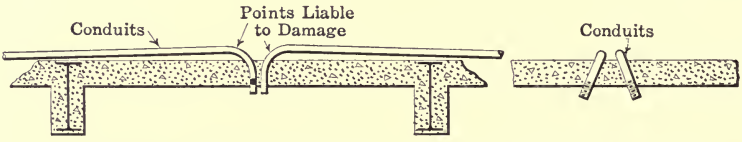


FIG. 2.—IMPROPER POSITION OF CONDUIT AND BENDS.

As the wooden forms which support the concrete mixture must necessarily remain in position until the mixture has hardened, a hole must be cut through the wooden form at the position where the outlet is to be located and the bent ends of the conduits placed therein. It is manifestly impossible to place the outlet box in position at this time owing to the wooden form. The laying of the conduit while the concrete filling is being placed saves much time, as it is a laborious process to cut through the concrete after it has hardened. With the present system of bending conduits it is also a bad method because the wheeling of barrows and the traveling of laborers and mechanics over the loose conduits throw them

out of position and produce the condition shown in Fig. 2. Where such a condition exists it is an expensive job to cut the hardened concrete around the displaced conduits and bend them into a position where an outlet box can be attached to them. It also invariably means that the outlet is moved from its correct position and the symmetry of the entire work destroyed.

The bending of conduit is also a laborious, time-consuming process, as the bends must be made about 5 in. from the end of the conduit because the concrete arches are seldom made more than 4 in. thick. If a larger bend is made the conduit projects upward and is more liable to damage from wheelbarrows and other causes. Figs. 1 and 2 show a correct and incorrect installation of bent conduits.

In exposed work the bending of conduit by the use of fittings on the market can be wholly eliminated, if desired, and the work made as satisfactory as by the older method of bending the conduit. The drawing-in of the wire becomes a simple task also. Fig. 3 shows a fitting the

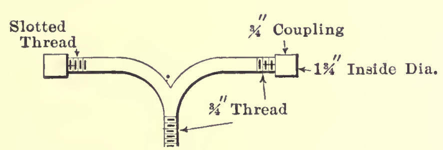


FIG. 3.—FITTING DESIGNED TO AVOID BENDING OF CONDUITS.

use of which will obviate the bending of conduits and which also provides a strong, substantial fixture support. The fitting, which can be made of malleable iron to withstand rough handling, is equal in external diameter to the standard 3/4-in. conduit. At each horizontal end the inside diameter is enlarged to 13/16 in. to a depth of 1 1/4 in. This allows the standard 1/2-in. conduit to slip into it. On each horizontal end a 3/4-in. pipe thread is cut to a point 1 1/2-in. from the end. Each end is then cut its entire threaded length, the cut being 1/16 in. wide. The thread will allow a standard coupling to be screwed upon it. When the coupling is screwed on it compresses the sections of the thread divided by the one-sixteenth cut and grips the 1/2-in. conduit, which is pushed into the fitting. After the conduit is pushed into the fitting and before the coupling is screwed on, an application of white lead or other water-resisting compound should be made to the thread. When the coupling is screwed on the thread it forces the compound into the crevice formed by the cut and makes a waterproof joint as required by the Underwriters.

The use of this fitting not only obviates the bending of the conduits, but it also saves the cutting of many threads. Under the present system the conduits are bent as desired, then measured and taken to a vise,

where they are cut and threaded. With this fitting the conduit can be cut where the fitting is being installed and as no thread is required the conduit can be pushed into the fitting, while lead is applied and the coupling tightened. A 1 1/4-in. hole can be bored through the wooden form sustaining the concrete mixture and the vertical portion of the fitting placed therein. A washer can be placed over it and by screwing a lock

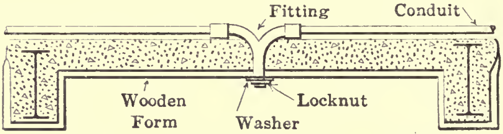


FIG. 4.—FITTING IN POSITION IN CONDUIT.

nut on the vertical end, which is also threaded, the fitting and conduit can be firmly clamped to the arch. Fig. 4 shows a fitting in place.

When the wooden forms supporting the concrete are removed the lock nut and washer can be removed and an outlet box placed in position by slipping it over the fitting, using the center of the box and forcing it

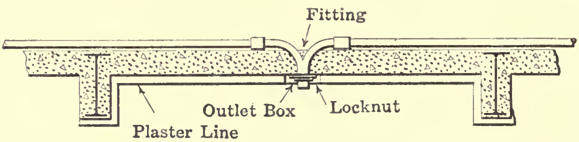


FIG. 5.—FITTING AND OUTLET BOX IN PLACE.

against the concrete by means of a lock nut. After the plastering is finished the rigidity of the box is greater because of the hardening of plaster surrounding the box. Fig. 5 shows a fitting and outlet box in position.

Conduit Systems in Concrete Buildings (By J. P. Morrissey).—Loss by experience in conduit work made the contractors cast about for some

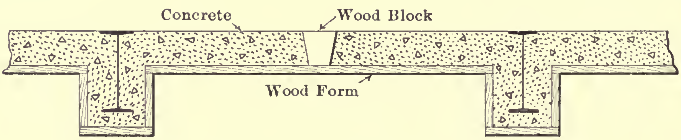


FIG. 1.—PROVISION IN CONCRETE FLOOR FOR OUTLET.

method of avoiding expensive and laborious punching, and finally a round wood block especially made to suit the construction and location on the wood forms at the location of the outlet was devised, as shown in Fig. 1. These blocks were made with a small diameter at the bottom of approximately the size of an outlet box and tapering to a larger diameter at the top, so as to prevent them coming out when the concrete forms

were removed. The blocks are of a depth to suit the thickness of the concrete slab construction. The concrete is poured after the block is properly set and fastened, and the opening in the concrete slab after it has set and the block has been removed leaves easy access for the installa-

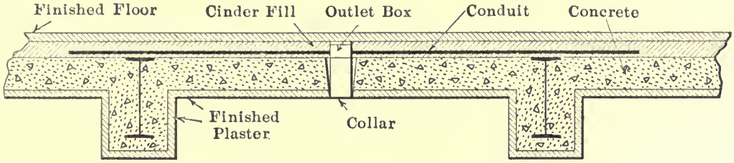


FIG. 2.—METHOD OF BRINGING OUTLET TO CEILING LEVEL.

tion of the outlet boxes and conduit. These blocks, being special, are expensive; therefore, much care is exercised in their removal.

After the blocks are removed one method of installing the conduit and outlets is to bring the outlet down flush with the ceiling, thereby necessitating sharp and small bends, depending on the allowable thickness

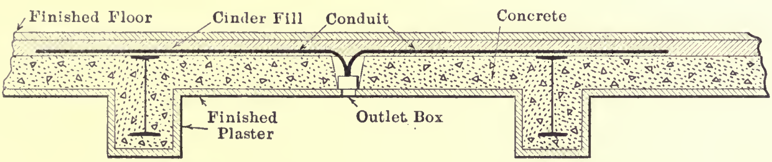


FIG. 3.—METHOD OF INSTALLING CONDUIT IN CONCRETE FLOOR.

of construction to the finished floor, so as to prevent its being exposed, as shown in Fig. 2. Where conditions will not permit such installation the outlet box is placed over the opening left by the removal of the block and the conduits are installed running into the side of the outlet box, properly and securely fastened. A sheet-iron collar is then made

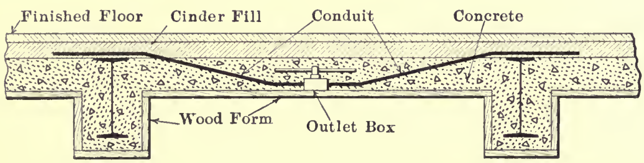


FIG. 4.—BOX AND CONDUIT EMBEDDED IN CONCRETE FLOOR.

up of the proper depth and bolted to the outlet box, thereby making a box to the level of the finished ceiling, as shown in Fig. 2. These methods do not prove very satisfactory, and the conduit and outlet boxes are now installed on the forms before the concrete is poured. This gives the most satisfactory results and adds greatly to the rapid completion of this class of building. The wood forms are set with the reinforcing

wire netting, and upon these the outlet boxes with one length of conduit are located, as shown in Fig. 4. The location for the outlet box is found and a nail is driven into the wood form at the exact center. The outlet box is made up with the fixture hanger securely and properly attached, and the center of the hanger is set over the nail at the outlet location. The box is then fastened to the form with wire nails.

The outlet boxes are deep enough to permit the conduit to enter on the sides. The conduit rests on top of the netting. In a great many instances the conduit actually is a reinforcement to the concrete construction and can be completed back to the distribution box location and be turned up or down at switch locations as conditions necessitate. This gets the conduit located out of harm's way and does not permit it to be trampled on or run over with wheelbarrows.

Galvanized iron and steel conduit have been used almost exclusively, and have proved satisfactory as far as results are concerned. The free use of white lead on all joints is a point insisted upon for the best results. The boxes used are also galvanized to withstand the corroding action of the concrete mixture. The wire nails that are used for fastening are so eaten by the concrete mixture that it is not a difficult job to remove them before pulling in the wire. Placing the outlet box flush on the forms brings it almost to the finish of the ceiling, which is very rarely thicker than the face ring which is added to the outlet box after the forms are removed. The fixture hangers, which have proved very satisfactory, are made up of a T fitting, into which a piece of conduit not less than 15 in. long has been inserted and a threaded stem installed, locking itself against the cross head and then being bolted to prevent turning. The stem is made long enough to come half way down in the outlet box, thereby leaving space for the insulating joint. Another fixture hanger that has given satisfaction when properly installed is made up with a "Thomas & Betts" loop head. A length of conduit is installed in the locp and a stem is screwed into the bottom of the loop and wedged against the conduit. A small nail is then driven into an opening for that purpose, which spoils the threads of the stem and prevents it from turning. The McKnight hanger has also given satisfaction, but requires care in installation. This hanger is all made up ready for installation, and it is only necessary to lock it into an outlet box with lock nuts, one on the inside and one on the outside, and then let it stand in a vertical position until the concrete is poured around it. The holding bands are then offset and fastened with nails at the points on the bands made for that purpose.

There have been instances where, because of the conduit being embedded in the concrete, spikes have been driven through the conduit to fasten sleepers for flooring, but the cases are very rare because the

more modern floors are of cement finish that do not require any spike driving. There are also instances where concrete has leaked in to conduits at joints, but this is faulty construction that might occur in any concrete construction. These are the only faults that have presented themselves.

Mitering Metal Molding (By G. A. Harris).—The following article describes a method of forming elbows and turns in metal wiring without

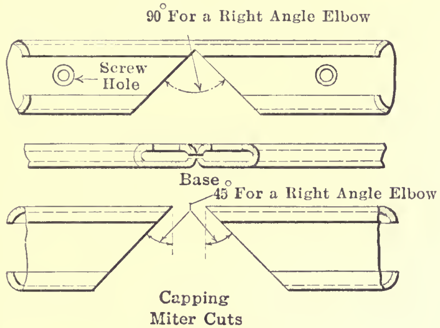
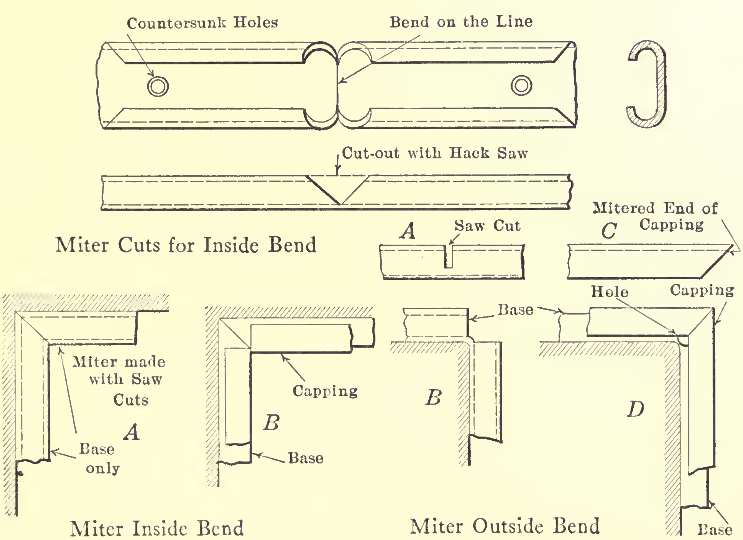


FIG. 1.—MITERED TURN



FIGS. 2, 3 AND 4.—MITERED ELBOW

the insertion of conducting pieces to maintain the electrical continuity of the molding. Fig. 1 illustrates how a piece of base is cut to form a right-angle elbow, leaving a portion of one edge intact to afford conductivity. After cutting the two ends of the base are bent together until the two cut faces abut. The two end lengths will then be at right angles

to one another. Cappings for such a 90-deg. elbow are mitered, as shown in the bottom of Fig. 1, and are snapped over the base after it has been erected. The base for an internal bend may be cut for a 90-deg. turn, as shown in Fig. 2. In Fig. 3*A* the base, which has been cut as outlined in Fig. 2, is shown in position in the corner, ready to receive the capping, and at *B* it is shown with the capping in position. It will be noticed that it is not necessary to miter the capping, as it completely incloses the slot in the base if pushed into the corner as suggested at Fig. 3*B*. For an external bend the base is cut with a hack-saw, as shown at *A* (Fig. 4), and is then bent and secured on the corner as outlined at *B*. The capping for an external bend should be mitered as detailed at *C*. When this is done there may be a small hole just at the apex of the angle included within the molding, as shown in the illustration, but this is of no consequence. In construction with conducting pieces, two screws or bolts are required at each turn or elbow to maintain the electrical continuity of the run. Where molding (as herein outlined) is electrically continuous, it can often be well supported by screws inserted through the holes punched in the base by its makers. Where this is done the extra labor of drilling additional screw holes and of driving the extra screws is avoided.

Erection of Metal Molding (By A. G. Tonstead).—Right-angle turns in metal molding runs are ordinarily made with metal-molding elbow

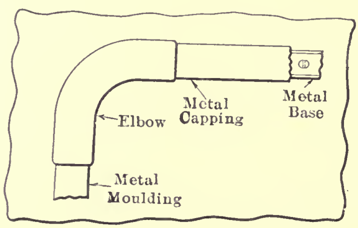


FIG. 1.—TURN MADE WITH ELBOW.

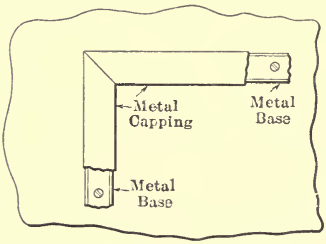


FIG. 2.—TURN MADE BY MITERING.

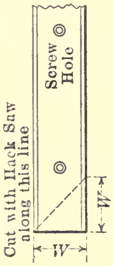


FIG. 3.—METHOD OF LAYING OUT A MITER CUT.

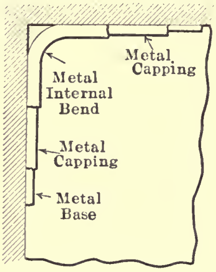


FIG. 4.—ELBOW FORMED WITH FITTINGS.

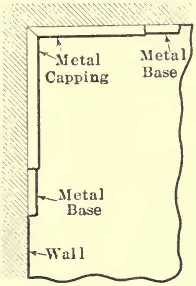


FIG. 5.—ELBOW FORMED BY MITERING.

fittings, as shown in Fig. 1. A more sightly turn can be made, without elbow fittings, as suggested in Fig. 2, by mitering the capping and base in much the same way as wooden molding would be mitered. The miter is cut with a hack-saw. A miter-box can be used to guide the saw or the cut can be made quite satisfactorily by laying off a distance, *W*, Fig. 3, equal to the width of the capping or brace, as the case may be,

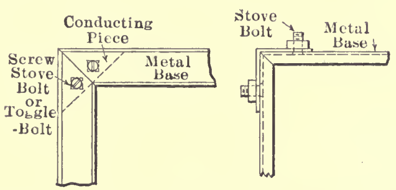


FIG. 6.—APPLICATION OF CONDUCTING PIECES.

along its side and indicating it with a pencil mark. The saw cut should be made connecting the corner of the molding with the pencil mark. After a wireman has done a little mitering he can judge, with his eye, the angle that the cut should take and can dispense with the miter-box and the marking. Metal molding is flexible enough to let it be bent to meet at mitered corners if the cutting is a little inaccurate.

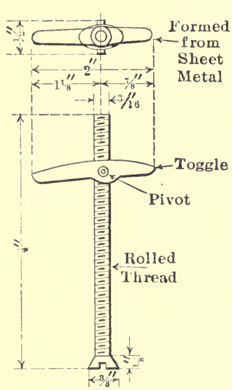


FIG. 7.—TOGGLE BOLT FOR METAL MOLDING.

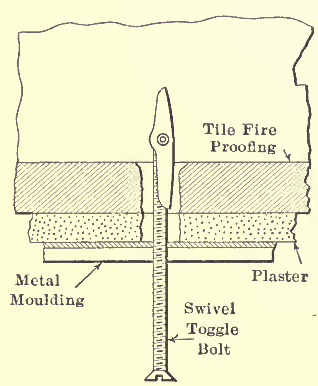


FIG. 8.—TOGGLE BOLT BEING INSERTED.

Elbows can be formed in somewhat the same way that turns are made. Fig. 4 shows the usual method where fittings are used and Fig. 5 shows how it can be done by mitering. It is required by the National Electrical Code that metal molding be so installed that adjacent lengths of molding will be mechanically and electrically secured at all points. Where work is subject to Underwriters' inspection, connecting pieces, cut from scraps of molding, can be inserted as outlined in Fig. 6, to join

adjacent lengths electrically and mechanically. Where molding is being erected on a wooden surface flathead wood screws can be used for supporting it and for effecting the connection between the conducting piece and the base pieces. (It is required by the code that the heads of any bolts or nuts must lie flush with the interior face of the base, after they have been inserted.) On concrete surface screws, turning into expansion anchors, or stove bolts can be used on tile fireproofing. Where stove bolts are utilized small cavities must be chipped in the supporting surface to accommodate the nuts, but it is often more convenient to chip these holes than to drill for an expansion anchor or a toggle bolt.

Toggle bolts, of the form detailed in Fig. 7, are well adapted for fastening metal molding to tile fireproofing. The bolt itself is threaded its entire length. The toggle is pivoted eccentrically and the long end tends to lie close to the bolt while it is being inserted, as shown in Fig. 8. After the toggle is through the hole it can be thrown into a horizontal position by twirling the bolt or by jiggling it up and down. Two sizes of toggle bolts are used for supporting molding. The 1/4-in. size shown is very satisfactory. The other size, 3/16-in., is a trifle light for all-around work. A length of 4 in., as suggested in Fig. 7, is about right for the average condition.

All holes drilled for supporting screws or bolts in metal molding base should be countersunk. A special bit for this work, having a square shank which fits the ordinary brace, is available. It is a combination drill and countersink, in that it drills and countersinks at one operation, and is a convenient tool. The base is usually drilled and countersunk by its manufacturers to accommodate No. 8 wood screws. These have a diameter of a trifle over 5/32 in., about No. 6 B. & S. gage.

Wiring in Metal Molding (By M. C. Rice).—Wiring in approved metal molding can be used for exposed work for circuits where the difference of potential is not over 300 volts and where the load does not exceed 660 volts.

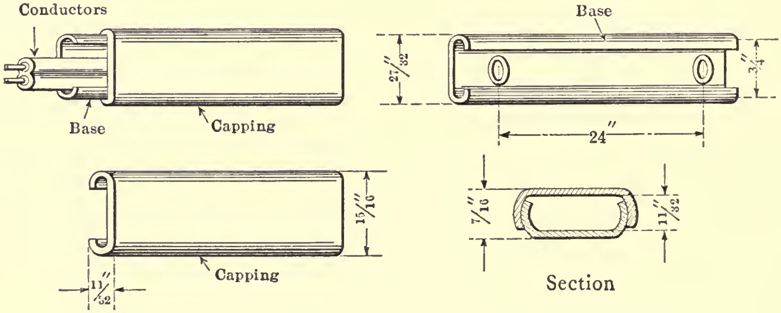


FIG. 1.—DIMENSIONS OF NATIONAL METAL MOLDING.

Metal molding must be continuous from outlet to outlet, to junction boxes or to approved fittings designed especially for use with metal molding. All outlets must be provided with approved terminal fittings, which will protect the insulation of conductors from abrasion, unless such protec-

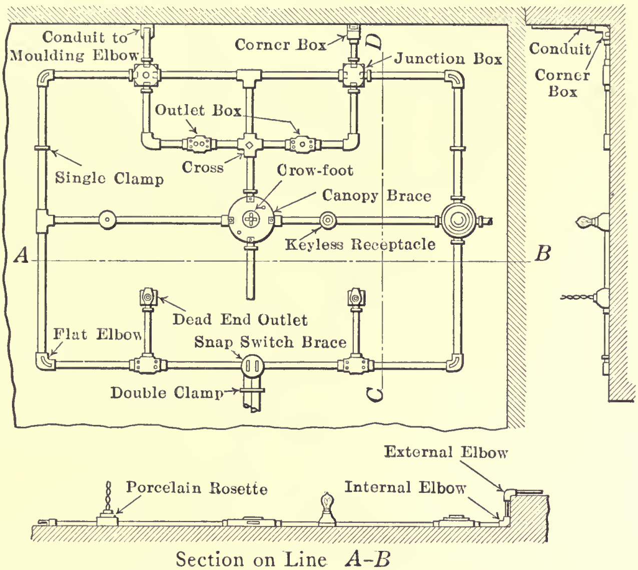


FIG. 2.—APPLICATION OF METAL MOLDING AND FITTINGS.

tion is afforded by the construction of the boxes or fittings. Metal molding should not be used in damp places.

Single-braid, rubber-insulated wire is approved. In all cases wires must be laid in and not fished. There is sufficient space in the channel molding shown in Fig. 1 for four No. 14 single-braid, rubber-insulated

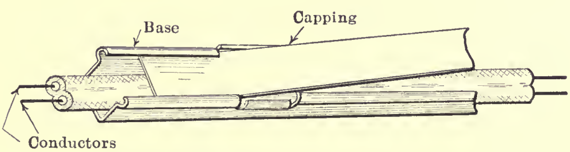


FIG. 3.—LUTZ METAL MOLDING.

wires. It is often necessary to insert this number of wires at double-pole switch loops, etc. The two or more wires of an alternating-current circuit must be in the same molding, and those of a direct-current circuit should be so that if a change is made to alternating-current reconstruction will not be necessary.

One common form of metal molding consists of channel capping that

snaps over a channel base. The principal dimensions are given in Fig. 1. It is furnished in lengths of 8.5 ft. and is "sherardized." Either water or oil paint adheres well to it. Because of the small space that it occupies it can be used to advantage on steel ceilings, in show windows, in showcases and in other locations where appearance is a factor and where safety is essential. The application of molding of this form is illustrated in Fig. 2—an imaginary lay-out shown to indicate how the material may be used.

Metal molding of another design consists of a channel-shaped base and a strip of sheet metal that slips in, as illustrated in Fig. 3, which constitutes the capping. It is electro-galvanized and is furnished in 10-ft. lengths. Capping can be removed at either end or at any other point desired by making two hack-saw cuts with a fine-tooth (tubing) saw through the flanges of the base and slightly opening the cut portion to release the ends of the capping. It is recommended that in making installations these hack-saw cuts be made at intervals to permit the future removal of the capping. Fittings for molding of this type are made somewhat similar to those illustrated in Fig. 2. All fittings are arranged to insure electrical conductivity throughout the molding installation.

Where metal molding passes through floors it should be carried through an iron pipe extending from the ceiling below to a point 5 ft. above the floor, which will serve as an additional mechanical protection and exclude moisture. In residences, office buildings and similar locations where appearance is an essential feature and where the mechanical strength of the molding itself is adequate the iron pipe can extend from the ceiling below to a point 3 in. above the floor.

Metal molding must be grounded permanently and effectively and so installed that adjacent lengths of molding will be mechanically and electrically secured at all points. It is essential that the metal of such systems be joined so as to afford electric conductivity sufficient to allow the largest fuse in the circuit to operate before a dangerous rise of temperature in the system can occur. Moldings and gas pipes must be securely fastened in metal outlet boxes so as to secure good electrical connection. Where boxes used for centers of distribution do not afford a good electrical connection the metal molding must be joined around them by suitable bond wires. Where sections are installed without being fastened to the metal structure of the building or grounded metal piping they must be bonded together or joined to a permanent and effective ground connection.

The metal-molding manufacturers provide fittings suitable for joining adjacent lengths of backing together and ground clamps (Fig. 3) for grounding. Lapping the capping from one length to the adjacent one constitutes an electrical connection. Ground wires must be at least

No. 10 B. & S. gage, although smaller wire is permitted in some municipalities.

In installing metal moldings the following suggestions will be found of value. Reasonable care should be exercised in separating the backing and capping preparatory to installation. As the quickest, most satisfactory method, hooking one of the punched holes in the backing over a convenient nail or screw and drawing the capping off is recommended. Except in cases where the backing of the molding passes through, under the fittings and is not cut, backing and capping should be cut before being separated in all cases. Because of the light stock, hack-saw blades having fine teeth and commonly known as "tube saws" should be used for cutting. Some construction men recommended marking deeply with a

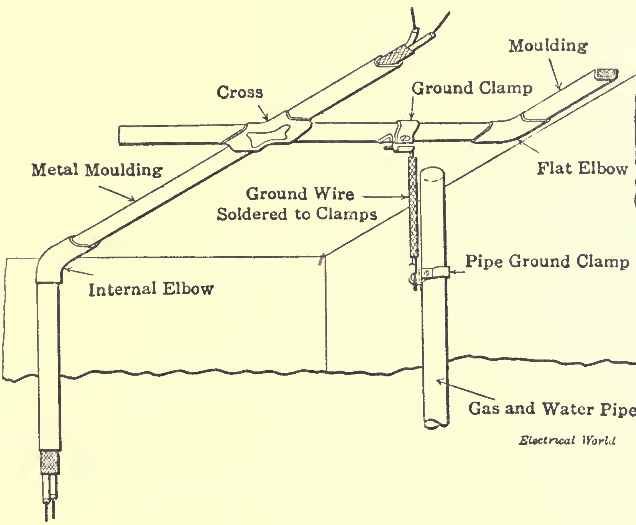


FIG. 4.—GROUNDING METAL MOLDING.

file and breaking. The molding is readily bent and, with reasonable care, may be worked to any radius down to one of 4 1/2 in. Bends must be made in all cases before backing and capping are separated.

The backing is punched and countersunk every 24 in. for the supporting screws or bolts. The support so afforded will usually be found more than ample, but further support may be secured either through additional punching with a special punch or by using a metal molding clamp. Fig. 8 of A. G. Tonstead's article on Erection of Metal Moulding, page 193, shows a toggle-bolt support as employed for metal molding. When the metal molding is installed on uneven surfaces, such as the ceiling of old buildings, the capping has a tendency to spring away from the backing. This may be overcome by the use of two or three straps fastened

over each length. If the capping of the molding is loose, it should be removed from the backing and tightened by tapping it with a mallet or hammer at points about 8 in. apart but on one edge only.

Metal molding can be mitered for elbows and bends by cutting it with a hack-saw. Elbows and bends thus made have the advantage that they fit into corners more closely than do the purchased fittings. Electrical conductivity is preserved by always leaving a portion of the backing intact.

Wiring in Cold-storage Rooms (By W. J. Canada).—If conduit is employed for wiring in cold-storage rooms, the effects of condensation should be minimized by the following general precautions:

1. Place all circuit fuses and switches outside of the rooms in substantial cabinets. The practice of using in the rooms cabinets kept partially dry by incandescent lamps is a poor palliative.

2. Use "brewery" cord and weatherproof keyless sockets. Attach the cords to the circuit wires mechanically in condulets or outlet boxes, solder them carefully, and warm the rubber tape in applying it.

3. Incline the conduit toward the outlet and junction boxes and leave these with opening to drain the attached conduit lengths, not, however, allowing them to drip in the attached sockets.

4. Repaint the conduit carefully at all joints and fittings, avoid short bends and repaint the entire conduit runs occasionally.

5. Have the conduit thoroughly bonded and grounded and test occasionally for leakage to and from the conduit.

6. Use alternating current if possible rather than direct current.

Where conditions seem to indicate the desirability of using open wiring, the following precautions will enhance the minimization of leakage for which this construction is alone employed and will tend to the reduction of chance grounds, crosses and injuries from mechanical disturbances:

1. Place the fuses and switches in substantial cabinets outside of the rooms.

2. Use "brewery" cord and weatherproof keyless sockets, supporting them directly from the wires, using carefully made joints, well cleaned, soldered and with the rubber tape applied warm completely covering the joints.

3. Support the circuit wires on petticoated insulators, maintaining unusual separation between the wires. Attach the cords near the insulating supports.

4. Where it is necessary to use bushings, if no mechanical injury is anticipated and the wire leaves the bushing parallel with it, use long porcelain tubes with at least 3 in. projecting on either side of the material through which the bushing passes. If mechanical injury may occur. use

properly drained conduit with the terminal condulet properly separating the wires and serving as a drip fitting. Where ice or frost accumulates conduit should be used because tubes are frequently broken in such locations.

5. Where much dripping from the ceiling occurs inverted wood or metal trough should be placed over the wires.

In either class of wiring the use of portable cords should be restricted, and if necessary marine cord and heavy guarded hand lamps should be used. It is frequently found that carefully made joints suffer less than expected from condensation and early development of grounds, and for this reason conduit is gaining favor.

Direct-current systems are not desirable for breweries, packing plants, creameries, etc., owing to the liability of trouble from commutators and brush rigging. Conduit wiring for alternating-current distribution will be the type favored for future cold-storage plants.

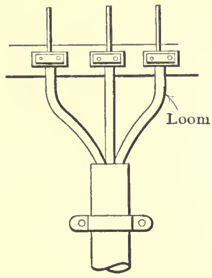


FIG. 1.—LOOMED WIRES IN CONDUIT.

Conduit Versus Openwork in places Subject to Moisture, Corrosive Fumes, Steam, Etc. (By F. G. Waldenfels).—The methods described have been found especially serviceable in wet places, hide cellars, tank rooms, fertilizer plants, glue houses, salt storages, casing rooms, excessively hot or cold places, etc.

Where ceilings are low the employees extinguish the lights by turning the lamp in the socket, thereby twisting the joints on the drop wires until the bare wires come together, causing a short-circuit and possibly flames that will feed along the conductors and set fire to combustible material. If the joints are not properly made, taped and then compounded, any amount of trouble can emanate from them. For such installations it is recommended that composition or hard rubber sockets be used. Porcelain sockets are too fragile in low places and are better suited for high ceilings. Corrosion can be greatly reduced in cabinets if the latter are maintained as dry as possible by keeping a lamp burning in each all the time. Snap-switch covers could be painted with asphaltum

or lacquer; the knife-switch blades could be painted with vaseline or lacquer; in fact, all the terminals on the cut-outs, etc., could be coated with vaseline to good advantage. Strange to say, brass T. & H. base-key sockets when protected have given better results in wet and steamy places than weatherproof sockets. They were first painted with white lead, then taped with friction tape, then painted again with white lead or asphaltum. The No. 14 stranded wires entering the 3/8-in. cap of the socket were first taped and then treated with compound to keep out the moisture. This gave a non-corrosive, unbreakable socket and the lamp circuit could be opened or closed with a key.

Corrosive Fumes and Salty Atmosphere.—Open wiring has always been installed in packing houses and other places subject to corrosive fumes, but there are several plants where sherardized and galvanized conduit have been in use for more than two years with very good results.

In places full of salty atmosphere, open work reigns supreme, but in spite of this fact some conduit is installed for the mains and rises, and this is holding out as well as the open work. The wires come from the floor above, in circular loom, which is inclosed in common galvanized-iron water pipe. (See Fig. 1.) The loom and the pipe are taped and shut with compound at the top to exclude water.

In hide cellars, the ceilings are about 7 ft. or 8 ft. high and open wiring is in the way and therefore always subject to mechanical injury. When a workman wants to extinguish any lights he simply turns the lamp in the weatherproof socket. This continual twisting finally affects the wires at the joints, breaking the strands one by one until the current is carried by only one or two strands of each polarity. When a circuit is reduced to this condition the small strands heat up or a short-circuit occurs and the ensuing fire readily runs up the wires to the ceiling.

The iron screws in the knobs are also attacked by the salty water, causing them to rust and expand, thereby cracking the knobs, especially if they are of glass, and allowing the wires to drop. In casing rooms an acidulous paste coats everything and destroys the insulation of wires and motors.

Pin and Insulator.—In places where the ceilings are high, over 9 ft., the pin and insulator system has given the best results, as far as insulating qualities are concerned; but this method of wiring requires much space and is constantly disturbed by the pipe fitter and mechanic. The construction is as follows: The hangers and cross-pieces are of 2-in. by 4-in. lumber, dressed and painted with red mineral paint. The pieces are fastened together with 3/8-in. galvanized-iron bolts, and the insulator pins are set and fit in holes in the cross-piece. Ordinary glass petticoat insulators are screwed on the pin and No. 12 B. & S. gage wire with a 3/32-in. rubber insulation is employed. It will be observed that the

rubber is just twice the thickness of ordinary No. 12 wire. Tie wires are employed to fasten the line wire to the insulator and for this purpose two ways are employed, as will be shown later. No. 14 stranded rubber-covered wires are used for the drops, and they are generally anchored from a standard No. 4 1/2 split knob. This knob has two grooves for the wires, while at the same time separating them an inch before being twisted. Very often the drops are anchored from the line wires after a few turns, before being fastened to the joints, but in this case such a method of anchoring is discouraged. The joints are a very important feature and should be made as described under another heading. Composition mica, porcelain or hard-rubber sockets should be used.

The pin and insulator system of wiring costs slightly more than a conduit installation. The extra cost arises from the use of the special 3/32-in. rubber-covered wire, which amounts to about $50 per 1000 ft., or about four times the price of ordinary rubber-covered wire.

Split Knobs.—Since 1911 the No. 4 1/2 split knob has completely replaced the solid knob in the Chicago territory. It surpasses the solid knob in that it does away with knobs and eliminates a great deal of the twisting of wires around knobs, thus prolonging the life of the insulation. Beside, there is a saving in labor because with split knobs it is necessary only to fasten the two ends and then fill in the intervening space with a knob every 4 1/2 ft. With the solid knob it is necessary to give the wire a turn around each knob, but with the split knob the wire goes straight through the knob. Different sets of grooves are provided for sizes of wires from No. 14 to No. 8.

Should a line support become broken or knocked loose, the line wire remains taut, another advantage possessed by the split knob over the solid knob. On the ends of the line some electricians prefer to use two solid knobs and wrap the wires around them figure-eight fashion, ending with a few turns around the line wire. A good electrician, however, can do as well with split knobs. The No. 14 stranded wire drops are also anchored from a No. 4 1/2 split knob, doing away with the knobs that were formerly used in a solid knob installation. Fig. 2 illustrates a satisfactory installation of knob work.

Fig. 3 shows another method of employing split knobs for line supports and at the same time anchoring the drop from the line wires. This is a very good scheme, as it enables one to do away with the anchor knob. The drop is anchored by giving the drop wire a few turns in front of the knob and a few turns in back of the knob before making the joint. There is, however, one objection to this scheme in that when an extension is attached to the socket all the strain comes on one wire.

Inverted "Tee."—Several packing plants employ the inverted "tee" method of wiring, which is second to the pin and insulator for good

insulating qualities. In this method use is generally made of the No. 4 1/2 split knobs for the line supports. The wood used is dressed 2-in. by 4-in. lumber painted with asphaltum. The knobs, Fig. 4, are turned upward so that the water cannot constantly run down them. Weatherproof sockets are anchored from split knobs on the line supports in the usual manner. This wiring is more expensive than the ordinary open work.

Knobs on Running Boards.—In places not subject to excessive moisture split knobs or separable knobs on running boards make a good installation. When passing under beams or other obstructions circular loom is employed between the supports. If switch legs are necessary,

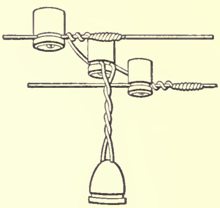


FIG. 2.

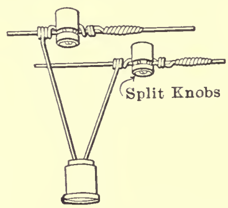


FIG. 3.

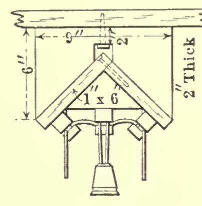


FIG. 6.

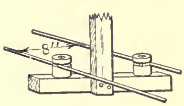


FIG. 4.

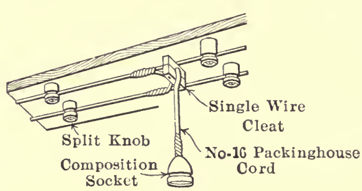


FIG. 5.

FIG. 2.—METHOD OF USING SPLIT KNOBS FOR SUPPORTING LINE WIRES AND DROPS.
FIG. 3.—METHOD OF ANCHORING DROPS FROM LINE SUPPORTS.
FIG. 4.—INVERTED "TEE" METHOD OF SUPPORTING WIRES WITH SPLIT KNOBS.
FIG. 5.—METHOD USED FOR INSTALLING SPLIT KNOBS ON RUNNING BOARDS.
FIG. 6.—INVERTED-TROUGH WIRING, USING SPLIT KNOBS.

they may be run down the wall or column in conduit, and snap switches should be mounted in a condulet.

The running boards are made of dressed lumber, 1 in. by 6 in., and painted with asphaltum or mineral paint. They afford protection from mechanical injury. If packing house cord is used for the drops, it is anchored with a pair of single wire cleats, but if stranded No. 14 wire is used it is preferable to employ No. 4 1/2 split knobs as the anchoring medium. This kind of construction costs about as much as conduit, and, that being the case, galvanized conduit would give far better results if properly installed.

Trough Wiring.—In excessively wet places and hide cellars inverted

wooden troughs (Fig. 6) have been installed with good results. In order to obtain a good job a carpenter should install the troughing, especially where obstructions are encountered, and an expert electrician should do the wiring. Special pains must be taken to get a tight waterproof joint.

The trough affords protection from mechanical injury and keeps water from dropping on the wires. Supporting blocks are placed every 4 1/2 ft. and the troughing is screwed to them. All the lumber should be dressed and painted. The supporting blocks should be 2 in. thick by 9 in. wide and the boards 1 in. thick by 6 in. wide. In some cases the trough alone costs 6 cents a linear foot. When to this is added the cost of the labor of carpenter and electrician it will be evident that the method is very expensive and costs much more than a good conduit installation. A small V-shaped block is screwed to the under side of the trough to

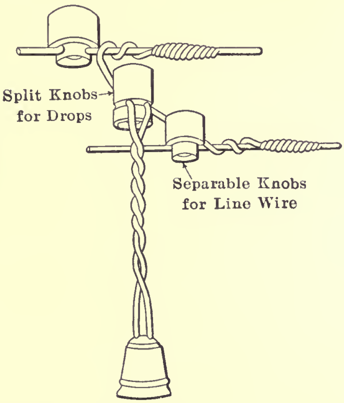


FIG. 7.—METHOD OF SUPPORTING LINE WIRE WITH SEPARABLE KNOBS.

hold the anchor knobs. No. 4 1/2 knobs have given the best satisfaction for line supports and drop anchors. The disadvantages of this system are that the wood rots rapidly and the initial expense is great. In one case of which the writer has knowledge the open wiring in the trough had to be replaced about every six months. Finally the chief electrician became tired of the constant rewiring necessary, and in 1911 he replaced the open wiring with galvanized conduit and cast-iron condulets. No trouble has appeared yet, and it looks as if it would last a few more years, although the conduit is in a very wet place and over offal tanks. Trough wiring can very easily be replaced with better results by properly installing the right kind of conduit.

Guard Strips.—On low ceilings where wires are subject to mechanical injury guard strips have served very well in many places. These strips are 1 1/2 by 1 1/2 in. square and are placed about 1 1/2 in. from the outside of each wire.

Separable Knobs.—The separable-knob construction (Fig. 7) makes an excellent job. The line wires are fastened at the ends to a pair of solid knobs (figure-eight fashion); then separable knobs are inserted every 4 1/2 ft. When the cap of this knob is screwed up tight it takes up slack in the wire, an advantage possessed by this type or knob over others; but the knob, on the other hand, is more fragile than a split knob.

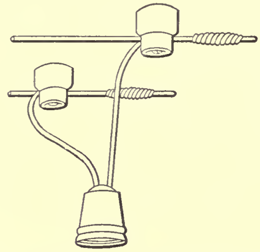


FIG. 8.—METHOD OF SUPPORTING LINE WIRES AND DROPS WITH SEPARABLE KNOBS.

All sizes of wires from No. 14 to No. 8 B & S. gage can be used with this knob, and the drop is generally anchored from a No. 4 1/2 split knob, as previously describe.

Fig 8 illustrates another method of installing separable knobs, where they are shown used as supports for line wires and at the same time for drops. This makes a serviceable installation of very low cost.

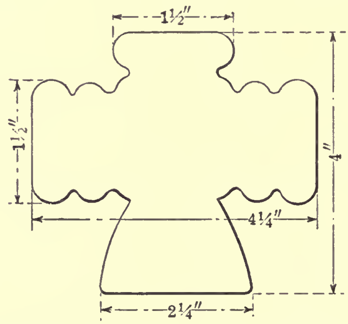


FIG. 9.—SINGLE SOLID PORCELAIN SUPPORT FOR BOTH LINE WIRES AND DROP.

Solid Porcelain Support.—A support that has been used almost exclusively in one plant for open work in wet and steamy places, is made of solid porcelain so thick that the breakage is negligible. It costs about four times as much as a split knob and a general installation costs nearly as much as a conduit job. The support is easily installed with a 3/8-in. by 5 1/2-in.lag screw. The insulator carries the two line wires and a place

is also reserved for the drop, which can be anchored from the line supports or from the individual part of the support reserved for it. As far as supporting the wires is concerned, an installation of this kind does not differ much from the old solid knobs which require a twist of the wire around each knob. But the small screws have been eliminated and

FIG. 10.—COMMON SPLICE.

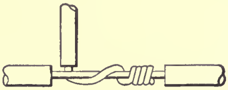


FIG. 11.—TAPPING A LINE WIRE.

replaced with one large one, and instead of two or three knobs they are all molded into one. The lag screws are dipped in compound before being used, and are thereby protected from corrosion.

Iron Brackets for Glass Insulators.—The original wiring of one packing house was installed with iron brackets and glass insulators screwed to a wooden pin, but this proved very unsatisfactory. In places subject

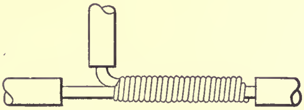


FIG. 12.—TAP FOR LARGE WIRES.

to moisture and corrosive fumes the metal arms practically vanished, allowing the lines to fall; the wooden pins swelled and cracked the glass insulators; the iron screws holding the brackets to the woodwork also corroded until the heads fell off, allowing the brackets to hang in any way. As fast as the circuits in this installation break down they are being replaced with circuits wired on supports, or solid porcelain No.

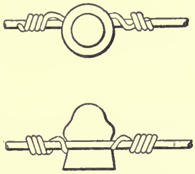


FIG. 13.—SINGLE-TIE METHOD.

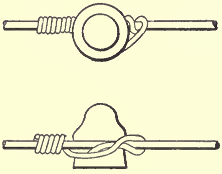


FIG. 14.—BACK-TIE METHOD.

4 1/2 split knobs, and lately a great deal of the best conduit has been installed in the very worst places with good results.

Joints.—Joints should be made as follows: When cutting the insulation the knife should be drawn slantingly toward the wire, not straight, or otherwise the wire will be nicked. The joint should at first

be so spliced as to be both mechanically and electrically secure. Fig. 10 shows how a common splice should be made, Fig. 11 the way to make a tap to a line wire, and Fig. 12 one way to tap for heavy wires. These joints are standard and are approved by all underwriters. All the wires for the joints should be scraped perfectly clean and free from insulation. In Fig. 10 the two ends are given several complete long turns, then the ends are given four complete short wraps. In Fig. 11 the wire is given two long turns for play room, then four short turns. In Fig. 12 the wires are bound together with a layer of No. 12 or No. 10 bare copper wire closely wrapped. In all cases the joints should be cleaned with a standard soldering flux and soldered with pure half-and-half solder.

For wet and steamy places the bare joint after being soldered should be thoroughly covered with insulating compound, which acts as a direct protection from moisture should water leak through the tape. Then rubber tape should cover the whole joint, followed by several tight layers of friction tape. Then for a good, permanent job the whole joint should be waterproofed by completely covering it with an application of compound of insulating paint.

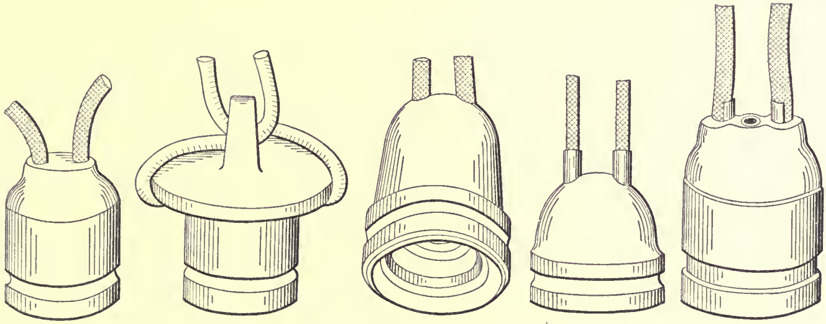
Tie Wires.—There are certain ways to fasten tie wires properly to hold line wires to insulators or knobs. Fig. 13 shows top and side views of an insulator to which the line is attached by the well-known single tie, made by bending a piece of wire about 12 in. long around the insulator and under the line wire with three or four turns on each side, the ends being cut off close. Fig. 14 shows a back tie. A piece of wire about 18 in. long is bent around the insulator under the line wire with 4 in. of tie on one side and the remainder on the other. The short end is then wrapped three times around the long wire, leaving a space equal to the diameter of the wire between each of the wraps. The long end is wound closely around the line wire two times, brought back around the insulator and wrapped three times around the line wire between the turns of the short end.

Wires.—The kind of wire used for open work is a very important feature of the installation. The rubber insulation must, to stand the severe conditions of moisture, salty atmosphere and corrosive fumes, be of very best quality. Ordinary single-braided wire with 3/64-in. rubber insulation would soon break down, but wire with 3/32-in. rubber insulation having in it about 30 per cent. para and being triple braided, gives very good results if the wiring is not subjected to mechanical injury. The cost of this special wire, however, is about $50 per 1000 ft., several times that of ordinary No. 14 rubber-covered wire, but the results obtained more than compensate for the higher cost. With this heavy insulation No. 12 wire is generally used for branches. If conduit were installed, the ordinary rubber-covered, double-braided duplex No. 14 New Code

wire would give as good results, and the wires would always be in a safe place.

Wires for Drops.—Best results have been obtained by using a pair of stranded No. 14 rubber-covered, single-braided wires for drop lamps. Ordinary commercial cord will not answer, and No. 16 rubber-covered, single-braided solid fixture wires (twisted pair) have been used most extensively in one plant in connection with taped and painted brass T. & H. base-key sockets, with satisfaction. For long drops packing-house cord is very good and is sometimes used, but it should be anchored with a pair of single wire cleats, otherwise it is difficult to provide and a good support.

Lead-covered Wires.—Many installations employ lead-covered wires supported on knobs and others where the lead-covered wires are inclosed in conduit. Each wire has a rubber insulation over which is a lead sheath. The lead affords a good protection from salty atmosphere, acids and mois-



FIGS. 15, 16, 17, 18 AND 19.—WEATHERPROOF AND VAPORPROOF SOCKETS.

ture. When supported on knobs, for fear of grounds collecting on the lead sheath which would make it alive, short strips of the lead are carefully cut from the wire, the spaces being taped and painted or compounded to keep the moisture from entering between the lead and the rubber. In some fertilizer rooms open work with lead-covered wire on knobs has not given the satisfaction expected. The wires were disturbed and broken by mechanical injury, making the installation very hard to repair; but on the other hand the lead affords a very good protection to the insulation from the peculiar acid and moisture found in such places. Where taps to the lead-covered wires are made for the drops the joints should be carefully compounded, taped with rubber and friction tape and then compounded again. It is essential in such work that every bit of the surface of the finished joints be covered with compound, because if there is a slight opening water and acid will eat through the tape and attack the copper, converting it into copper sulphate.

Lead-covered cables have also been employed in several buildings as risers. In some cases the cable is inclosed in a length of conduit which extends 2 ft. below and 8 ft. above the floors on the side wall as a protection from mechanical injury, the cable for the rest of the distance to the ceiling being supported on knobs. In other cases the cable is closed in continuous conduit throughout all the risers. As a whole an open lead-covered installation is very undesirable.

Sockets.—The choice of sockets is more or less a gamble. Porcelain weatherproof sockets are fragile and cannot stand rough usage. Many porcelain sockets can be found broken after six months because moisture runs down the wires into the top of the socket and with the assistance of heat finally cracks it. On many old porcelain sockets a sulphur compound was used for sealing purposes, and this when moistened caused the socket to crack on a change of temperature. The newer sockets have a filling compound which will not crack the socket when subject to moisture and heat.

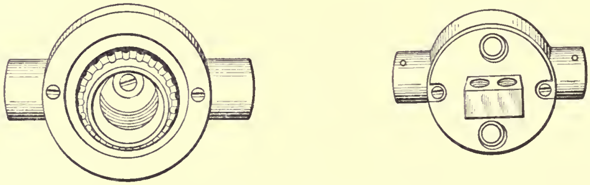


FIG. 20.—CONDUIT BOX SOCKET AND OUTLET.

For high ceilings in wet places, where the drop lamps are out of reach, composition and mica sockets have lasted very well. No sulphur is used in these sockets for sealing purposes, and therefore they do not crack open easily; but, on the other hand, excessive heat will melt them. On low ceilings, however, pigtail sockets should not be used, because of the twisting of the joints due to the practice of switching the lamp on and off by turning it in the socket. The hard-rubber molded or mica sockets, however, are best and cheapest for use on reasonably high ceilings in wet places. They will not crack like porcelain sockets, can withstand extra hard usage and are constructed even better than the vaporproof socket by having a solid body of composition supporting the shell.

Vaporproof sockets give fair results if the outer globe is always on and if they are not exposed to mechanical injury. They cannot withstand any hard usage, however, and this is a requirement which generally must be fulfilled in steamy places. The main trouble is that the screw shell is not properly surrounded with a porcelain body, and the bare shell is too weak for ordinary use.

Rigid weatherproof sockets when installed in outlet boxes give satisfaction, especially on low ceilings where the employees habitually extinguish the lights by turning the lamps in the sockets. The porcelain part of the socket should be notched and fitted into a notched metal cover to prevent the socket from turning. Of course, where the ceilings

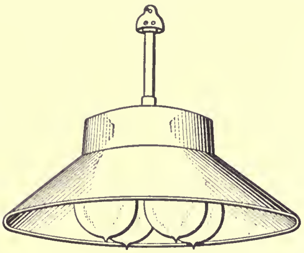


FIG. 21.—WEATHERPROOF CEILING CLUSTER.

are high and the lamps controlled by switches are out of reach the drops are not so objectionable.

On very low ceilings, where a rigidly supported lamp and receptacle are impracticable on account of liability to mechanical injury, it is advisable to install conduit with porcelain covers, which permit the use of short pigtail weatherproof sockets, without joints between the lamp and the

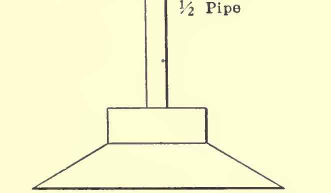


FIG. 22.—METHOD OF HANGING LAMP CLUSTER.

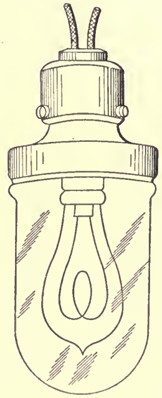


FIG. 23.—VAPOR-PROOF INCANDESCENT LAMP.

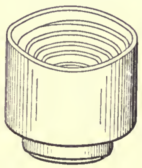


FIG. 24.—ADAPTER.

porcelain cover. Pressed-steel condulets give excellent results because they do not break at the shoulder if there should happen to be a side strain on the conduit, although they frequently crack in the seams. For protection against moisture and corrosive fumes, however, the cast-iron outlet box or condulet has not been excelled. There is also a sherardized

steel condulet and outlet box on the market that has given good results in such places. When lamp sockets are empty it is wise to plug them with a tight-fitting cork to keep them from corroding.

Clusters.—Waterproof clusters are employed to great advantage where the ceilings are at least of medium height. Clusters that have given the best results have been equipped with an enameled shade. They are made up with a 1/2-in. pipe stem about 12 in. long and are fitted with a porcelain body for the lamp receptacles, or with individual sockets protected by a white enameled shield, which permits the sockets to project through it about 1/4 in. Extensions can be attached to these clusters without harm. The clusters are generally hung from a hook in a swinging position—a very favorable feature. Where corrosive vapors abound, it is advisable to suspend the clusters from malleable-iron or cast-iron hooks.

Another method of hanging a cluster so as to allow it to swing in two directions only is shown in Fig. 22. Here two pieces of pipe fastened to a T-condulet are strapped to two floor joists and the pipe stem of the cluster is screwed into the condulet.

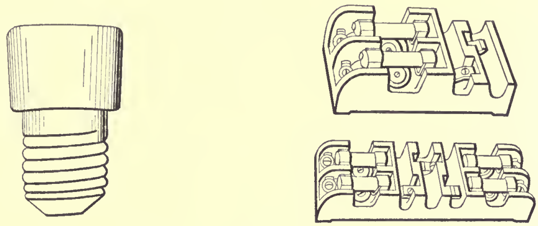
Incandescent Lamps and Adapters.—The type of incandescent lamp in general use has an Edison, or screw, base, but the T-H, or bayonet, base lamp has given the least trouble. As a protection to life the T-H-base lamp is the safest to use in wet places, because there is no live screw shell to come in contact with as in the case of an Edison-base lamp, in which the shell is continued from the socket to the lamp and very often projects beyond the socket about 1/4 in. The projecting shell is fraught with danger to employees, especially where 220-volt alternating-current circuits are used for lighting. Rather than pay the extra 3 cents per lamp several packing plants have switched over to the Edison base by using adapters or have replaced the T-H socket entirely with a weatherproof Edison base socket.

Edison-base adapters have recently been employed where a change has been made from the T-H base lamp with poor results. There are many reasons for this: first, the lining of the adapter absorbs moisture like a sponge, causing short-circuits in the sockets; second, if a lamp is unscrewed with the circuit alive the arc holds and burns the thin contact ring in the base of the adapter; third, if in a brass-taped and painted key socket equipped with an adapter the circuit to the lamp is interrupted by means of the key, the arc will invariably hold on 220 volts and burn off the metal ring in the base of the adapter.

Cut-outs and Snap Switches.—On 110-volt circuits the Edison-plug cut-outs are very satisfactory, provided the cut-out bases are mounted on 1/2-in porcelain knobs, cleats or hard-rubber tubing. Not to mount them would be folly and cause no end of trouble due to the film of mois-

ture which forms between the terminals and the material of the wet cabinet and readily affords a path for the passage of electricity.

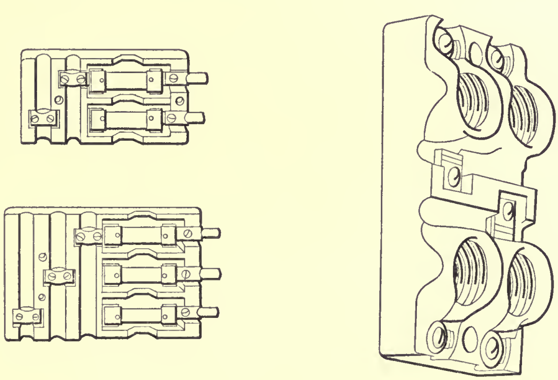
Fuses.—Some electricians prefer the inclosed cartridge-plug fuse, claiming that its use limits any chance of employees getting a shock when the fuses are backed out of the receptacle, because of the large porcelain cap which fits over the plug. Until recently these fuses were approved for use on 220-volt circuits. They were a great deal safer to handle in



FIGS. 25, 26 AND 27.—CARTRIDGE-PLUG FUSE AND CUT-OUTS.

wet places than the ordinary cartridge fuse of to-day, but one great disadvantage is that an inspector cannot tell the size of the fuse in them.

For 220-volt lighting circuits in damp places cartridge fuses and porcelain bases are required by the Chicago underwriters. The bases should also be mounted on 1/2-in. porcelain knobs, cleats or hard rubber. Pains must be taken to see that the ferrule contacts fit tightly around

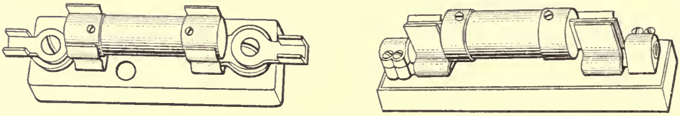


FIGS. 28, 29 AND 30.—FUSE CUT-OUTS.

the fuse. In this case also the inspector must guess at the size of the fuse in the cartridge. If the cut-out cabinet is tight and well constructed the underwriters would under most circumstances prefer link fuses with copper tips, provided there was a barrier between each set to keep the hot metal from the fused one from reaching an adjacent fuse. Par-

ticular pains should be taken to fasten wires under all terminals properly, because a loose contact causes heat and very often melts the fuse.

Up to 60 amp., 250 to 600 volts, the ferrule-contact cartridge fuse may be used for motors, provided the proper spacings are kept for the different currents and voltages, and from 60 amp. to 600 amp., 250 volts, and to 400 amp., 600 volts, the knife-blade contact must be used, provided the proper spacings as specified in the National Electrical Code are followed. These fuses render good service for the motors, but from an inspection standpoint it is difficult to tell what size of fuse wire is in a



FIGS. 31 AND 32.—CARTRIDGE FUSES WITH CUT-OUT BASES.

cut-out that has been refilled without removing it from the base, thereby necessitating the stopping of the machinery to examine it. Concealed fuses create a doubtful feeling in the inspector, and many inspectors would prefer good link fuses to refilled cartridge fuses, provided the cabinets are tight.

On heavy circuits it is imperative to note that all the strands of the cable have been soldered into the lugs which are connected to fuse bases, as it has been found that electricians very frequently cut off the outer strands of a cable to make the latter fit a certain lug. It is also important

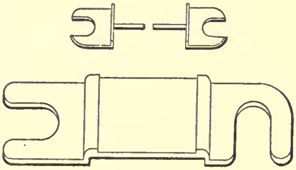


FIG. 33.—LINK FUSES..

FIG. 34.—SNAP SWITCH.

to see whether cables have been properly sweated into lugs during the soldering process by vigorously shaking the cable near the lug.

Link fuses for lamp and motor circuits, if installed in good, tight cabinets, are the safest and most satisfactory protection that can be employed in packing houses. It is also very easy in such installations for the electrician or the inspector to assure himself that a wire is not over-fused and that the motors and devices on those circuits are therefore well protected from overloads. Slate or marble bases must be employed for link fuses, and it is advisable to have a barrier across the base between

the breaking gap. All link fuses should be provided with copper tips, otherwise a good contact is not made under the screw terminal. With large link fuses it is advisable to note that the proper breaking distance has been maintained across the gap, otherwise if the fuse blows the metal will crystallize across the gap, permitting leakage of current.

Snap and Knife Switches.—For lamp circuits snap switches are safest and fulfil the requirements. Small knife switches are too dangerous in damp places, especially where foreign laborers are employed. The greatest trouble experienced with the ordinary snap switches is due to the paper lining under the metal shell. This absorbs moisture, swells and causes short-circuits between the screw terminals inside and the outside metal shell. To prevent corrosion, the metal cover should be treated with a coat of asphaltum or lacquer. All snap switches should be mounted on 1/2-in. porcelain knobs, cleats or hard-rubber tubing.

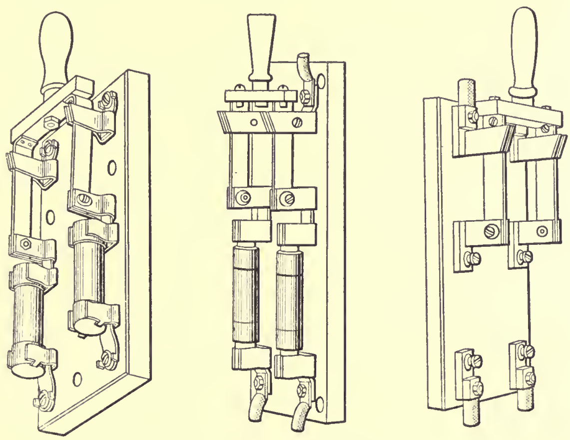


FIG. 35.—FUSED KNIFE SWITCHES.

Snap switches with porcelain shells have not proved satisfactory in packing houses on account of rough usage. It is advantageous to have the key work on a socket so made that it cannot be unscrewed. There is, however, a snap switch for wet places on the market that has a composition hard-rubber cap 1/8 in. thick, and covers to fit different switches can be bought separately.

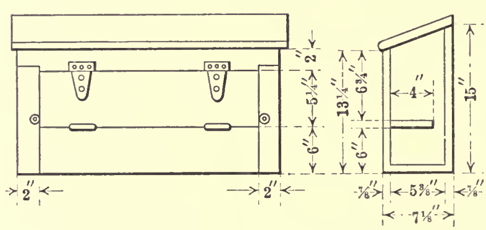
On an ordinary knife switch several defects can be found that cause excessive heating. A large switch that is frequently opened and closed will loosen up at the hinges; the nuts also work loose, releasing the spring washers, and very often the lugs or wires are not screwed down tight at the terminals. All these defects lead to heating.

Electricians frequently use a heavy pair of pliers to screw a small nut down on a wire. If too much force is used the threads are stripped

and the terminal is generally left in that state, because to remedy the defect would necessitate taking down the whole switch base to replace the stripped screw. It might be well also to call attention to the cartridge-fused knife switch, in which the jaws of the switch are at the same height as the ferrule or knife-blade contact of the fuses. When the switch is opened and thrown against the fuses the switch handle and blades act as a lever and wedge against the fuses, enlarging the clips and causing the contacts to heat when in circuit because of the loose connection.

When purchasing switches it is desirable to choose those of heavy construction. The terminal screws should be heavy enough and of sufficient length to fasten the wire or lug with two heavy nuts, one of which acts as a lock nut. To protect switches from corroding in damp places the metal parts should be painted with lacquer or vaseline.

Extensions, Lamp Guards, Sockets, Etc.—In running an extension in wet places packing-house cord or elevator cable should be used. It should be equipped with a weatherproof socket inclosed in a substantial



Kind		*X*
3 Cutouts		11"
Main	Branch	
1	5	1'9½"
1	6	2'7"
1	7	2'4½"
1	8	2'8"
1	9	2'11½"
1	10	3'3"

FIG. 36.—STANDARD WOOD CUT-OUT BOX.

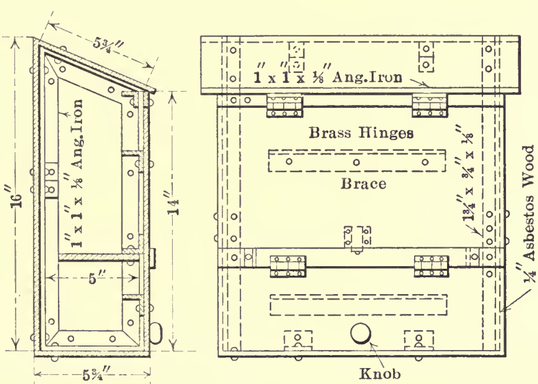
wooden handle having a strong brass, galvanized or bronze guard, with the end open so the lamp can be replaced if necessary. At the other end there should be provided an approved composition or hard-rubber, separable-cap attachment plug, each part to be inclosed in a brass shell. Where the cord enters the handle and cap of the attachment plug it should be taped and compounded. In plants operated with 220 volts, alternating current for lighting, special outlets should be provided for extensions and the pressure reduced through transformers to 55 volts.

Metal guards protect the lamps from breakage, from coming in contact with combustible material, and many also protect the lamp from theft. One type is locked to the socket with a key. For protection against corrosion the metal should be hot galvanized iron or brass. For outside use where exposed to the elements, copper-plated lamp guards have given the best results, especially around cattle pens.

Wires stay up only about as long as the screws last. Several schemes of treating ordinary steel wood screws have been tried. Hot galvanizing

has given good results except that threads cannot be cleaned very well. Another method for protecting them is to dip the screws in hot compound or insulating paint. Brass screws are best provided the heads are not broken by hammering them too hard.

In packing houses, the brushes and commutators of direct-current motors cause a great deal of trouble, and the sliding contacts on rheostats also become rough and burnt. In one case the motors had to be replaced so often that finally one was mounted on very strong brackets on the exterior of the building wall. A housing of hot galvanized metal large enough to allow a man to pass all around it was constructed around the motor and a line shaft or belt run through the wall to operate the machinery inside the building. This motor (Nov. 1912) has now been running about a year and is still in excellent condition.



Inside Dimensions		
Cutouts		Length
Main	Branch	
1	1	9.5″
1	2	1′-1.5″
1	3	1′-5.5″
1	4	1′-9.5″
1	5	2′-1.5″
1	6	2′-5.5″
1	7	2′-9.5″
1	8	3′-1.5″
1	9	3′-5.5″
1	10	3′-9.5″

FIG. 37.—ASBESTOS WOOD CABINET.

In fertilizer buildings direct-current motors seem to operate well, except when they heat up from an overload. Then it seems the heat assists the fertilizer powder in some mysterious way to break down the insulation of the windings. For wet places the alternating-current, squirrel-cage-type motor and compensator have a decided advantage over the direct-current equipment because of the absence of sliding contacts.

Cabinets.—Wooden cut-out cabinets in the past have had the preference in most packing plants. The wood is mostly 7/8-in. pine, and the inside width of the cabinet is generally 6 in., the height 13 in. and 15 in. when a pitched roof is used, and the length varies with the number of cut-outs. In older boxes the inside is lined with 1/8-in. or 1/4-in. asbestos, fastened with 3/4-in. tacks and well painted with asphaltum or insulating paint. In wet places the top is made slanting. Other boxes

are constructed with the bottom 2 or 3 in. wider than the top, so that the door will always have a tendency to swing shut.

Other wooden cabinets have the top and bottom of the same width and are equipped with a glass door which is raised like a window. The window allows the switches and cut-outs to be visible all the time, a great convenience, especially when a lamp is kept burning inside the cabinet. This light acts as a pilot and shows the way to the cabinet for the employees, when they enter the place in the dark to throw on the circuits.

All cabinets should be mounted at least 2 in. from the wall on large flat porcelain knobs. This spacing allows plenty of ventilation, a great advantage and necessity in wet places. Small and medium-size cabinets should always be equipped with doors so mounted that gravity will tend to close them. Catches of all description have been tried, both wooden and metal, to keep the doors closed, but none as yet has been found satisfactory. The wooden ones are broken off in a short time and the metal ones corrode off. The best method is to make the bottom of the door heavier than the top by fastening a metal strip along the outside edge, or provide a round metal weight, allowing it to act at the same time for a knob with which to raise the door. All kinds of hinges have been tried, such as spring hinges and leather hinges having a nail through a metal strip, steel, galvanized, etc., but the hot galvanized iron or brass hinge is best in packing-house work.

To protect employees from live contacts, some companies provide an asbestos-lined board shield in front of the knife switches and fuses, mounted on two wooden pins which fit in holes in the bottom of the cabinet. This shield may be lifted out of its place when access to the fuses is necessary.

In Fig. 37 it will be observed that the main door is divided into two parts. On the upper door there is a barrier projecting at right angles into the cabinet. This is only another means of protecting employees from coming in contact with fuses when operating snap switches. The upper compartment is for the main cut-out and all the fuses, the lower one is for snap switches only. The upper half of the door is screwed tight, while the lower one may be opened any time. All wooden cabinets are now lined with 1/8-in. asbestos board, because ordinary asbestos absorbs too much moisture, no matter how well it is painted.

Wires should enter wooden cabinets preferably at the bottom through porcelain tubes properly taped and compounded. In many places conduit is used for risers and branch circuits, in connection with wooden cabinets. The conduit for the branches reaches to the ceiling only, then the circuit is continued as openwork. In cases where water is apt to run down the outside of the pipe into the cabinet flooring pitch should be poured around the conduit where it enters the cabinet.

Asbestos-wood Cabinets.—It is essential that a cut-out cabinet be fireproof, and in places where metal cabinets are not favored a cabinet made entirely of asbestos wood could be employed to advantage. Asbestos wood is unaffected by flames or intense heat of any form. This material will not warp even when in a highly heated condition water is thrown on it, and in addition to being fireproof it is also moisture-proof. It is excellent for cabinets, and in one large plant several have been made as an

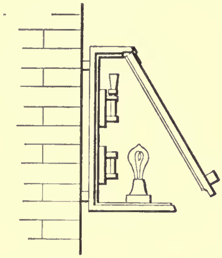


FIG. 38.—SWITCH AND FUSE CABINET.

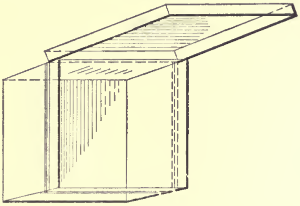


FIG. 39.—HOT-GALVANIZED STEEL CABINET.

experiment and installed in a tank house. The construction of the cabinets is interesting. At first an angle-iron frame was made from 1-in. by 1-in. by 1/8-in. metal and fastened with copper rivets. The thickness of asbestos wood used was 1/4 in. and 3/8 in., the 3/8-in. stuff being used for the top and doors. Heavy brass hinges were employed and all fastenings were made with copper rivets. The asbestos wood running lengthwise overlapped the sides. Bushings were used where the wires en-

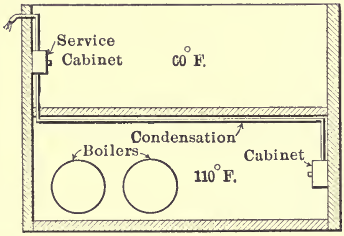


FIG. 40.—CONDENSATION IN CONDUIT OVER BOILERS.

tered the bottom of the cabinet. The cabinet, which was constructed with double compartments, cost $6.

Steel and Cast-iron Cabinets.—Enameled-steel cabinets are not satisfactory for damp places, being susceptible to corrosion. A good hot galvanized-steel cabinet of No. 12 U. S. metal gage, however, has proved very serviceable, having been tried in one of the worst places—a glue house. In this place a steel cabinet was installed and it fell to pieces in

four months. Then a hot galvanized cabinet replaced it over a year ago, and with the exception of turning perfectly white, the cabinet looks as good as the day it was installed. The steel hinges, however, corroded away and had to be replaced with brass ones. The door of a steel cabinet, if not too large, should close by gravity. The four edges of the door should be turned at right angles 3/4 in. and close against a rabbet all around the box. A metal stop should be fastened on top of the cabinet, so that the door cannot be raised too high and left in an open position. A metal strip should also be fastened on the bottom part of the door to act as a weight. One can rest assured that this kind of door will always be found in a closed position, because it cannot be left open unless held up by a stick. Such a cabinet will be found moisture-proof and dust-tight.

The cast-iron cabinet is on a par with the hot galvanized steel cabinet, as far as service is concerned. It will not corrode, but it costs more and will break easily. With conduit installations the cast iron has to be drilled for each pipe where with the steel cabinet the knock-outs are depended upon to insert the conduit.

Conduit.—Up to the present time ordinary conduit has been charged with two deficiencies, corrosion and condensation. Whenever ordinary conduit was installed in places subject to moisture and corrosive fumes it invariably corroded and scaled off very readily, leaving only the shell of the conduit hanging on the wire. In this state the insulation of the wire also soon broke down, making the installation hazardous.

Experiments with all kinds of conduit have been carried on for three years in a place where conditions are severest. With the different kinds of conduit a piece of hot galvanized water-pipe was also installed, after being closely examined for burrs inside the pipe. Strange to say, all the conduit was attacked and a great deal of it was completely eaten away, but the hot galvanized water-pipe turned white and is still doing service for a motor, having three alternating-current feeders in it, and it looks as good to-day as when it was installed. About 50 ft. of lead-covered flexible steel-armored conductor was tried in the same place, with water-tight fittings, and an examination after four months showed it was corroded, even the lead straps holding the cable in places being pitted.

The success of hot galvanized water-pipe caused the writer to visit some of the conduit manufacturers, with a view to encouraging them to manufacture a hot galvanized conduit. One company, however, had been experimenting for the last four years trying to put a hot galvanized conduit on the market at the same price as the other conduit. In this it was evidently successful and produced a hot galvanized pipe that could withstand seven to ten one-minute dips in a standard solution of copper sulphate at a temperature of 65 deg. Fahr. Other types of conduit do

well if they can withstand five one-minute dips. March, 1912, a sample of the hot galvanized conduit was nailed to a joint in the glue house mentioned, and within a few months turned white, which is a sign of long life, no corrosion being visible.

Corrosion.—Ordinary conduit has given fairly good results in many places where the worst conditions of moisture, etc., prevail; but some locations are more severe on conduit than others. In several places where the conditions were very severe, the conduit being subjected to steam, ammonia and sulphur fumes, about every fifth piece of conduit was slightly corroded and about every tenth piece of length was corroded completely through. The rest of the conduit turned completely white and showed no signs whatever of corrosion. This shows that all conduit is not uniformly treated during the process of manufacture, because then none of it would have corroded. To ward off corrosion and make the ordinary conduit last longer, several electricians have painted the conduit

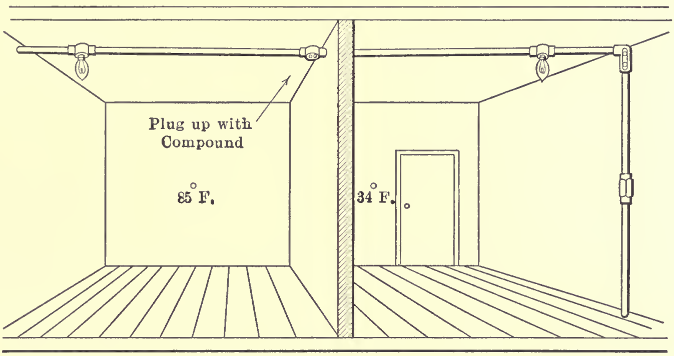


FIG. 41.—INTERCEPTING AIR PASSAGES IN CONDUIT.

before installing it. Best results have been obtained by using a silicate graphite paint. Others tried insulating paint or asphaltum and also obtained good results, especially where the conduit was exposed to the steam from the hog. Still others have painted the conduit with aluminum paint and find it very satisfactory in a place where ordinary conduit lasted only two months.

Despite the inequalities of ordinary conduit it has served fairly well. Of course, one must not expect too much from an ordinary soft-steel pipe, especially in places where conditions are very severe. Hot galvanized pipe, however, has persisted in places where the ordinary conduit cannot stand up and is therefore to be commended for packing-house work.

Condensation.—Condensation can be eliminated in a conduit installation in two ways—one by draining the conduit between outlets by gravity and the other by plugging up or by interrupting the air passages in the conduit at positions where different temperatures are encountered.

Where steam and alternating temperatures prevail condensation is sure to exist, and in such a case the conduit should be drained between the outlets by installing another outlet with one or two holes in the por-

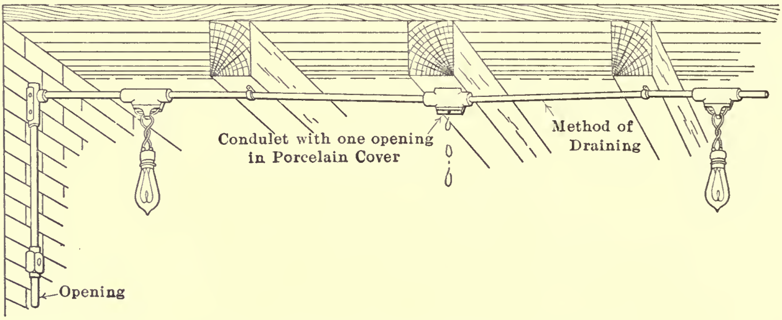


FIG. 42.—PROVISION FOR DRAINING CONDUIT.

celain cover to let the water out. Referring to Fig. 42, it will be observed that there is a drain outlet between the two lamp outlets, and also that the conduit has a drop toward the drain outlet so the water can run out

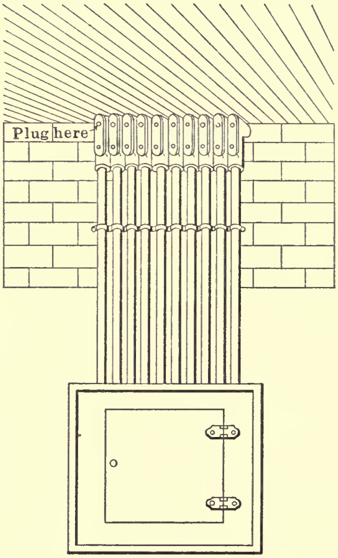


FIG. 43.—METHOD OF AVOIDING CONDENSATION.

by gravity. If switch legs are installed on the walls or columns, a hole should be left open in the bottom of the box.

Fig. 44 shows the same method of draining, when the conduit extends from a room with a temperature of 75 deg. Fahr. to a room having a

temperature of 34 deg. Fahr. Fig. 41 shows another method whereby condensation can be eliminated. If the conduit is plugged in the outlet at the partitions, as shown, then there will be no condensation. Otherwise, if the air passage were not interrupted, the hot and cold air would come together and condensation take place. At the partition an outlet box is installed in the conduit system and the pipe is plugged up and carefully sealed with insulating compound. This work should be very carefully done, otherwise if there is only a small air passage condensation will take place. Fig. 43 shows conduit risers for branch circuits from a passageway with a temperature of 75 deg. Fahr. to coolers of 34 deg. Fahr.

Another method of interrupting the system is to end with outlet boxes at the partition and piece the partitions with open wiring through porcelain tubes. This method is not, however, to be encouraged, because equal

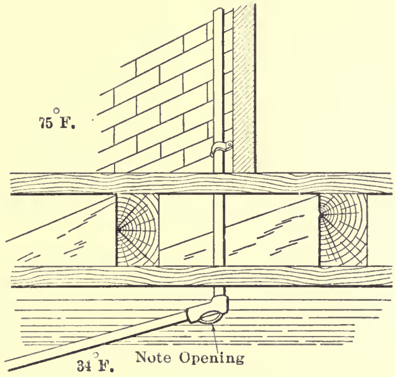


FIG. 44.—METHOD OF DRAINING CONDUIT.

results are obtained with the former methods, and of the three draining is preferable.

Cast-iron Outlet Boxes.—Cast-iron outlet boxes should be installed in wet places, because a steel box corrodes too readily. The conduit should be white-leaded before being screwed to the outlet boxes or jointed. It is also well to provide a gasket between the cover and the boxes, to keep the water from the joints as much as possible.

Lead-covered Flexible Steel-armored Cable.—Of the two places where 50 ft. of lead-covered flexible armored cable was installed, one was in a large pickling establishment, where salt water condenses on the ceilings and walls. The cable after thirty months' use showed not the slightest sign of corrosion. The other 50 ft. of cable was installed in a glue house, and after three months' use was corroded, especially that portion of it over the liquid tanks. In a glue room everything is covered with an acidulous paste, which readily attacks iron and steel, but galvanized

metal withstands the sulphur and ammonia well. Lead-covered, steel-armored cable, however, has been very serviceable in a great many other places.

Conduit Versus Open Wiring.—As compared with regular open wiring, such as two-piece knobs and ordinary code wire, conduit is ordinarily about twice as expensive. As compared with the higher class of open wiring, such as the inverted "tee" or the pin and insulator system using 3-32-in. rubber-covered wire, a conduit installation is cheaper, the pin and insulator system costing almost twice as much. Comparing conduit work with a job using split knobs on running boards, the cost would be about the same. Considering all the good points of the best open wiring and not mentioning the hazardous ones, from an underwriter's viewpoint a hot galvanized conduit installation, properly installed, is at least 100 per cent. better.

Instances of Condensation in Conduit.—To show the effect of condensation in conduit, a few packing-house examples are cited herewith. In these cases the water was trapped in the conduit at its lowest point and in time the insulation on the conductors rotted and broke down, resulting in a short-circuit or a ground which burned a hole in the conduit. The worst cases have happened at service entrances. At these points the conductors enter the building in conduit, there being no fuse between the transformer and the fused service switch. If a short-circuit or a ground occurred between these two devices, it would have to burn itself clear either by melting the wires or by puncturing the conduit. On the other hand, if water collects in a conduit where the circuits are equipped with fuses, the fuses provide the protection desired, in case the regular fuse has not been replaced with a strip of metal or copper wire.

In one case of condensation which happened in a basement ceiling over some boilers, the service wires in conduit entered the building at the ceiling of the first floor and passed to a fairly tight cabinet in a cold room on the wall about 5 ft. above the first floor, where was installed the fused service switch. The conduit ran from the cabinet through the basement ceiling and along the ceiling over some boilers to a distributing cabinet. When cold weather came the fuses in the service cabinet blew continually. Investigation showed that some of the conduit over the boilers was full of water. This was due entirely to condensation. Cold air entered at the service pipe and traveled down through the service cabinet, then continued until it encountered the hot air in the conduit above the boilers. The temperature in the basement was very high and on the first floor it was very low, and the consequence was that condensation took place when the hot and cold air met. The trouble was eliminated by providing an outlet box with a 1/2-in. hole in the cover, directly where the conduit entered the ceiling of the basement. (See Fig. 40.)

In another case the service wires entered a room that was very hot and steamy. The circuits for the lamps in this room were wired in conduit which came from the cut-outs in the main or service cabinet. The result was that the cold air entered the service conduit from the outside and traveled along until it entered the cabinet, and here it diffused itself into all the warm conduits in the room, the condensation gathering at the lowest part of the pipe system. The trouble was remedied by providing an outlet box at the point where the conduit entered the inside of the room and plugging the entering pipe with compound. (See Fig. 41.)

If conduit is bent around the beams of a room that is steamy and is subjected to alternating temperatures, condensation is sure to take place, and the water will be trapped at the bends. The best remedy is to provide a "tee" condulet or outlet box at the bend, to act as a drain.

To drain conduit some electricians may attempt to drill holes in the pipe at the lowest point in the line. This should not be allowed, because a hole drilled through the shell of the conduit will expose the plain steel, which is not galvanized, and in a very short time the hole will be corroded shut, thereby ending its usefulness, and at the same tine damaging the conduit.

Installation of Conduit.—The following are names of places where conduit has been installed, with remarks as to the life and condition of the conduit:

Cold-storage Warehouse.—Enameled conduit was installed seven years ago as an experiment. Some of the conduit was run continuously from the cabinet in the passageway where the temperature was about 68 deg. Fahr. to the cold-storage rooms having a temperature 10 deg. below zero. Some of the conduit was plugged shut at the partition in the passageway. All the conduit is in good condition; in fact it all looks like new, and there is no condensation or corrosion in either case. This is probably due to the extreme cold condition.

Cooler or Hanging Rooms.—This is a room where the cattle hang and steam after being killed. Sherardized conduit is plugged at the partitions as shown in Fig. 41. In three years no condensation or corrosion is visible.

Tank Rooms.—In these places the offal of the plant is boiled over into fertilizer by a process in which sulphur and ammonia are used. The steam readily attacks metals. The particular building in question is constructed of reinforced concrete. Exposed sherardized and galvanized conduit was used for wiring and was installed two and one-half years ago. Ninety per cent. of both types approximately turned white and are doing good service; the other 10 per cent. of both types of conduit was practically eaten away. This installation was made in the usual way and was not drained or plugged. About 90 per cent. is holding out pretty well and

that a long life is assured after the metal turns white. The other 10 per cent. was very easily replaced with little cost.

Glue House.—Thus far no kind of conduit, except some hot galvanized water pipe, used as an experiment, has been able to withstand the attacks of fumes in this place. Every kind of conduit on the market was tried but all corroded rapidly. A section of hot galvanized water pipe has been in service three years, and since it has turned white it will probably last many more years. This experiment has demonstrated that hot galvanized pipe is what must be installed to withstand successfully the severest conditions encountered in packing-house work.

Borax Mill.—About three years ago a room in which borax liquid is allowed to steam and crystallize was wired in enameled conduit. The installation is still in excellent condition and no corrosion whatever is visible.

Canning Department.—A canning department was wired with enameled conduit and cast-iron boxes seven years ago. Recent inspection revealed that the conduit was only slightly attacked over the boiling tanks. The rest was in excellent condition.

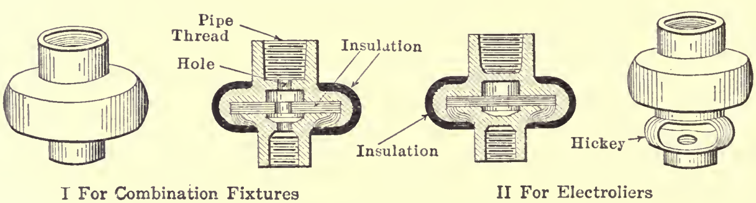


FIG 1.—INSULATING JOINTS.

Pickling Department.—In this place salt water is continually condensed on the ceilings and walls. Enameled conduit and galvanized conduit have been installed fifteen months and drained as shown in Fig. 42. Both are in excellent condition, and no grounds have occurred yet. In another instance lead-sheathed, flexible-steel armored conductors had been in use over thirty months and were still in very good condition.

Fertilizer Rooms.—Several are wired in conduit but not in damp or wet places. Any first-grade conduit should give good satisfaction. Wet fertilizer attacks all conduits very readily.

Hair House.—Conduit has given good results with cast-iron boxes, except in dyeing rooms or in damp places. With hot galvanized conduit, properly drained, it should be feasible to wire every part of a hair house in conduit.

Oleo and Oil Houses.—Conduit gives excellent results wherever there is plenty of grease. Over the scrap kettles steam had caused some trouble, but if the proper conduit is employed and drained no trouble should ensue.

Insulating and Supporting Fixtures (By R. H. Cronin).—Insulating joints are used to insulate fixtures from grounded parts of a building. The wiring spaces within fixtures are so confined that grounds are very liable to occur in them. If the fixture is insulated from the grounded parts, one ground within it is not liable to do harm. Fig. 1 shows some

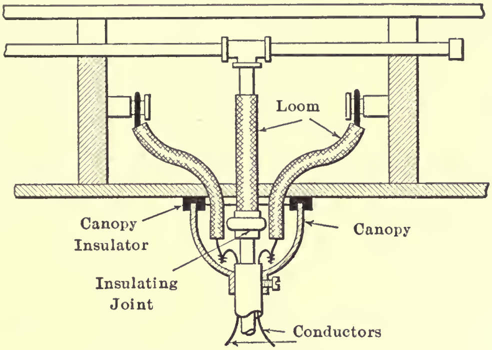


FIG. 2.—INSULATING JOINT FOR A COMBINATION FIXTURE.

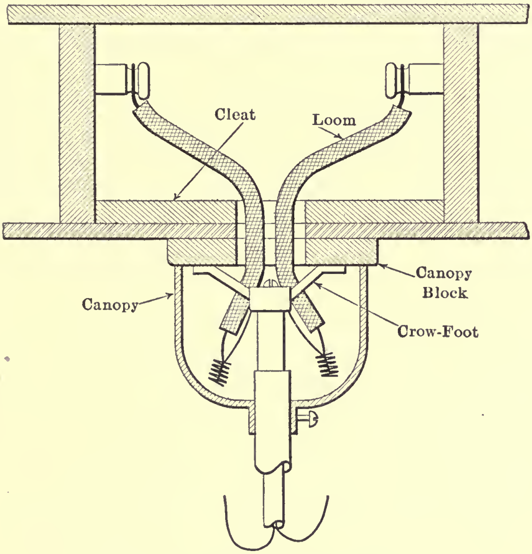


FIG. 3.—ELECTRIC FIXTURE SUPPORT.

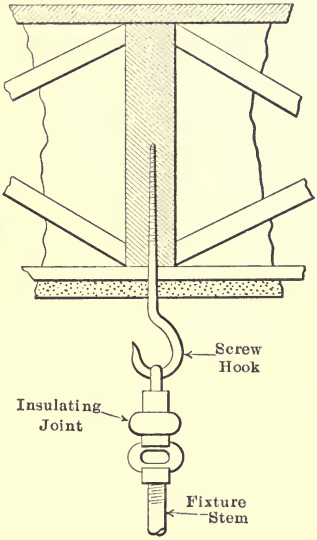


FIG. 4.—SUPPORT FOR A HEAVY FIXTURE.

insulating joints. That at I is used for combination gas and electric fixtures. It has a hole through it to permit the passage of gas. That shown at II is for electroliers and has no hole through it.

In insulating combination fixtures the insulating joint should be located as near as feasible to the ceiling, and the wire ends left after con-

necting should never be twisted around the supporting pipe above the joint. (See Fig. 2.) Flexible tubing is required on the wires in knob and tube work and it should extend below the joint. The code requires that the pipe above the joint be protected with insulating tubing, which may be either a heavy wrapping of tape or circular loom.

Fixtures can be supported in frame buildings by the method of Fig. 3. A wooden strip or cleat should be fastened just above the lath during the construction of the building to take the screws to hold a canopy block. The wooden canopy block supports, with wooden screws, the fixture crowfoot and insulates the canopy from the ceiling. A screw hook turning into a joist (Fig. 4) can be used for sustaining heavy fixtures in frame buildings. A special insulating joint having an eye is inserted in the fixture stem to insulate the fixture from the ceiling, or a chandelier loop can be used on a regular insulating joint. In fireproof buildings where fix-

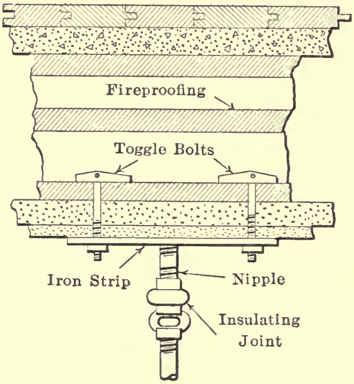


FIG. 5.—SUPPORT FROM A FIREPROOF CEILING.

tures must be erected after the building is completed an iron strap (Fig. 5) held to the surface of the ceiling with a couple of toggle bolts can be utilized for supporting a fixture. A pipe or conduit nipple turning into a threaded hole in the strap takes the weight of the fixture.

Fixture canopies can be insulated from ceilings and walls with commercial canopy insulators, of which there are many forms on the market. Canopies are usually supplied already fitted with insulating rings by the fixture manufacturers. Where canopy insulators must be "homemade" the method of Fig. 6 or that of Fig. 7 may be followed. In Fig. 6 a ring of fiber formed from the sheet material is bent to fit the interior of the canopy and is held therein with wires or small rivets. The ring should extend about 3/8 in. above the top edge of the canopy. Another canopy insulator, sometimes termed a "bug" insulator, can be sawed from block fiber, as shown in Fig. 7. The upper edge of the canopy rests in a slot

sawed in the "bug." At least three such insulators should be used for every canopy. A small nail or wire driven through a hole in the insulator and one in the canopy holds each "bug" in position.

Connecting Cords in Sockets (By C. Broadhurst).—In fastening cords in sockets some precaution should be taken to prevent stray strands of wire from coming in contact with metal and thereby causing short-circuits or grounds. This can be accomplished by dipping the bared

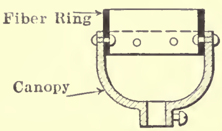


FIG. 6.—FIBER-RING INSULATOR.

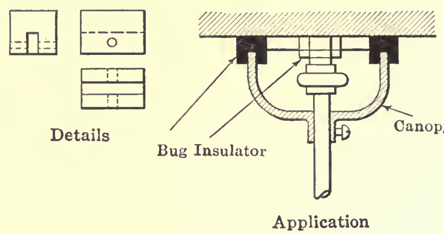


FIG. 7.—BUG INSULATOR.

conductor of the cord in molten solder before it is made up under the binding screw. Strips of tape about 1/4 in. wide, torn from wider pieces, are sometimes wound about the braid at the end of bared cord, to prevent the braid from unraveling. A fairly good method of fastening a cord in a socket is to cut half of the conductor away, twist the remaining strands into a little cable and then make it up about the screw. Tape should be applied as shown in the illustrations, Fig. 1.

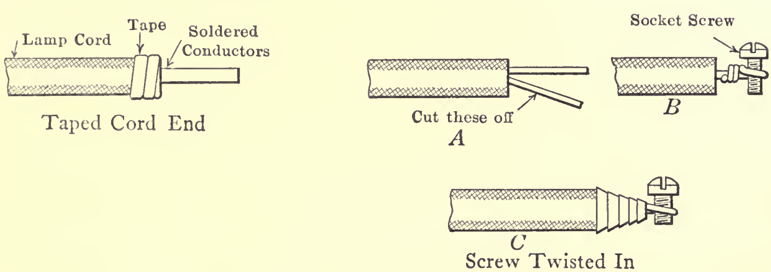


FIG. 1.—FASTENING CORDS IN SOCKETS.

Electric Vacuum Cleaner for Fishing Conduit.—A Richmond (Ind.) contractor was perplexed as to how to "fish" wires through a 0.375-in. gas pipe for a newel-post lamp. The pipe had three bends in it and could not be disconnected. A friend suggested to him that he get an electric vacuum cleaner on the job. When the cleaner was brought the two men took a piece of string and made a ball of the string nearly as large as the opening in the pipe. Leaving the remainder of the string attached, they inserted the ball in one end of the pipe and put the smallest nozzle on

the cleaner hose at the other end and sucked it through. The entire operation took about two minutes, and after they had a string through the pipe they were able to draw the wires after it without any further trouble. By this method they accomplished a task in less than five minutes which a man had tried to do by hand for the greater part of the previous day.

An Improvised Pendent Switch (By Roger P. Heller).—A pendent switch being urgently needed and none being at hand, the writer recently made use of an ordinary key socket with a rubber cord-bushing. The insulating collar and the brass shell or clamp was short-circuited by screwing a copper washer, about the size of a dime, under the central screw originally intended to connect with the center stud on the lamp. The open socket was then plugged with a cork of suitable size, pushed in flush, with the exposed end blackened with india-ink, after which it was treated to a coat of shellac. This arrangement was found preferable to the ordinary push-button pendent switch, as the latter must be steadied by the fingers or the other hand, whereas the improvised switch requires only a simple twist on the key, the counter-balancing torque being met by the cord.

X

MOTORS, MOTOR SWITCHES, GENERATORS, ETC.

Installation, Maintenance of Parts, Testing, Adaptation to Circuit Conditions, Etc.

Motors Housed in External Sheet-iron (By A. T. Todd).—The accompanying Fig. 1 shows the unusual but very successful arrangement employed in the installation of several motors to drive wood-working machines in a box factory at Pueblo, Col. The motors, aggregating about 40 h.p., are located in sheet-iron "lean-tos" or additions to the main building, all of the interior of which is thus free for manufacturing operations. Completely inclosed as the motors are, all risk of fire is eliminated. Each machine is belted down to a line shaft in the basement beneath the main workroom, and from this in turn the various planers,

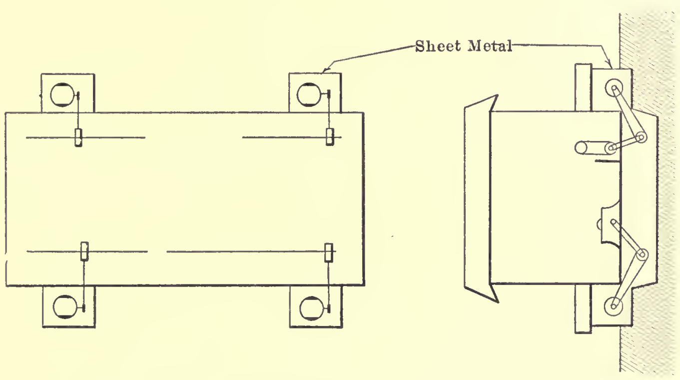


FIG. 1.—MOTORS HOUSED IN EXTERNAL SHEET-IRON.

saws, jointers, mortisers, etc., are driven. As the motors are on the main-floor level, they can be reached easily for inspection or repair. At the same time they are well located in a good dry place, and no power apparatus intrudes on the main floor to be in the way of the workmen.

Installation of Motors in Dirty Places (By M. O. Southworth).—Motors in dusty places generally accumulate an entirely needless amount of dust and dirt, because if it is not possible to give them complete protection they generally receive none at all. A light platform or canopy a few feet above the motor will keep off perhaps two-thirds of the dust, as

most of it settles down from above; a barrier a few feet higher and a little wider than the motor, raised from the floor, will often shield it from a lot more, and in this way the daily cleaning, even in very dirty places, will often be reduced to a very small matter. Barriers raised from the floor are especially effective in wood-working plants, where shavings and sawdust are usually projected in a definite direction from the machine producing them and can therefore be easily intercepted.

Installing Motors under Severe Dust Conditions (By N. H. Cicero).—In installing some motors in a stone-grinding mill where fertilizer material is manufactured, it was necessary to take unusual precautions to protect the motors against thick dust. Even induction motors could not be successfully installed in the same rooms as the mills because the dust affected the bearings and lubricating systems. The motors were therefore located in "doghouses" erected on the roofs of the buildings and from

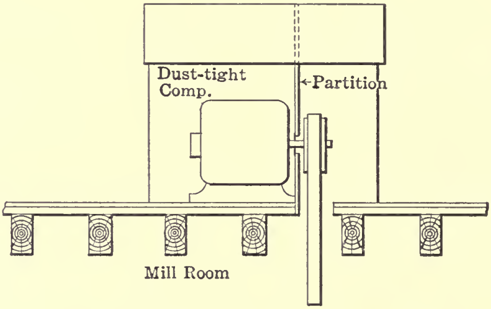


FIG. 1.—MOTOR PROTECTED FROM DUST.

their pulleys belts were brought down to the machines to be driven. Each motor proper was entirely inclosed in its "doghouse," a partition extending down between its frame and the overhanging pulley. The space between the partition and shaft was then closed by heavy felt wipers which bore on the shaft and rendered it impossible for any dust to enter the motor compartment. A year's experience with this construction proved its practicability.

A Home-made Iron Switch Box (By A. G. Trout).—An iron switch box can be readily made, as illustrated on page 231, of sheet metal. The box is bent from the sheet metal which is indicated at development. The cover is formed in the same way. After being bent, the sides are held in position with rivets. Holes are punched for conductor outlets and ordinary tubes are used in them for insulation. The switch boxes must be painted and they must also be made of metal not less than No. 12 U. S. metal gage (0.109 in. thick) to comply with code requirements. The hinges for the door are riveted on. Holes are provided in the back

for securing the box to the wall and for supporting the switch within it with stove bolts. There must be a space of at least 1/2 in. between the walls and the back of the box and the nearest exposed current-carrying part.

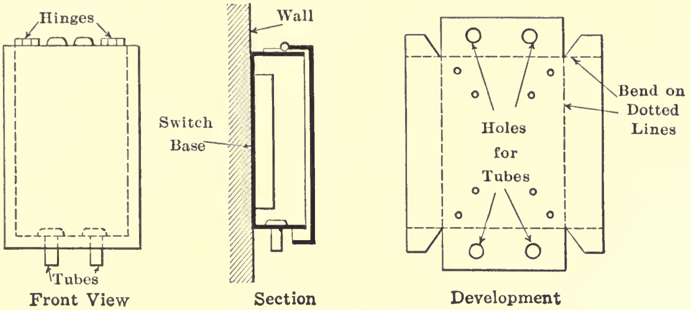


FIG. 1.—HOME-MADE IRON SWITCH BOX.

Design of Wooden Switch-boxes (By Harry Burrows).—Wooden switch boxes can be readily made. Iron ones are preferable, but their cost is often prohibitive. Wooden boxes (Fig. 1) should be of at least 3/4-in. well-seasoned wood and lined with 1/8-in. asbestos, secured in place with screws or with tacks and shellac. Sheet iron of at least No. 16 U. S.

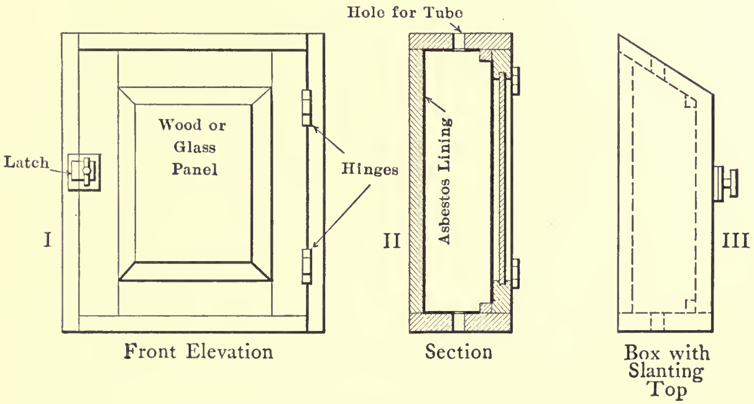


FIG. 1.—HOME-MADE WOODEN SWITCH BOX.

metal gage may be used instead of asbestos. The door should close against a rabbet so as to be dust-tight. Where a door is wider than, say, 12 in., it should be paneled with either wood or 1/8-in. glass, if of an area not greater than 450 sq. in., to insure against distortion due to warping. A space of 2 in. should be allowed between fuses and the door. A reliable catch should be provided on the door. Porcelain tubes or other approved

insulating bushings should be used for reinforcing the insulation on the wires where they enter the box, and these should fit the holes snugly. Where necessary, wires should be taped so as to fill completely the holes in the bushings. Bushings reaching just to the inside of the box should be used, as longer ones will be broken. It is recommended that, for factory use, the top of the box be slanted as at III (Fig. 1), so that it will not be used as a shelf. A box should be thoroughly filled and painted before it is lined.

Several switches, either snap or knife, can be mounted in a box like that of Fig. 1; in fact, it might be used as a panel box. A box or cabinet similar to that of Fig. 2 is often convenient, in that it is not necessary to open the door to manipulate the switch. The heavy iron wire handle can

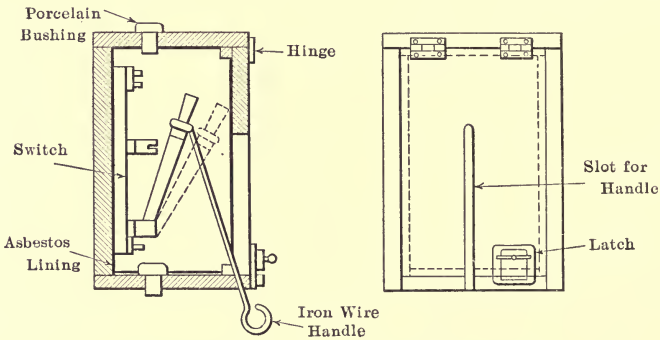


FIG. 2.—ENCLOSED WOODEN SWITCH BOX.

be attached to the switch by bending it around the wooden handle, or the wooden handle can be removed and the wire fastened with a nut or a screw eye. Wooden or composition cabinets must not be used on metal conduit, armored cable or metal molding systems. If the wooden cabinet is lined with sheet iron, the latter must be painted or treated in some way which will prevent corrosion.

Supporting Motors on Concrete Building Ceilings (By C. G. Jasper).—Reinforced-concrete industrial buildings are now so common that the progressive contractor should be familiar with the best methods of installing motors in them. It is conceded that the best location for a motor of a capacity of less than, say, 50 h.p. is on the ceiling. There it is out of the way and does not occupy floor space. A good induction motor does not require much more consideration than a shafting hanger.

As a rule motors inverted at ceilings are held from stringers of some sort. Either timbers (Fig. 1) or structural steel sections (Fig. 2) can be used for stringers. Wood is cheaper, but introduces combustible material in what might otherwise be a fireproof installation. Wood also shrinks and swells. This results in loose bolts, vibration and noise. However,

wood is largely used because it can always be readily obtained and can be erected by any carpenter. Although somewhat more expensive than wood, structural steel members constitute ideal stringers. When firmly bolted into place they stay there. If an installation is properly laid out it is not necessary to drill the channels or other sections forming stringers. They can be clamped into place, as suggested in Fig. 2, without drilling. A discussion of methods of mounting motors is really one of supporting stringers, as after stringers of any reasonable design are in place the motor bed-plate can be bolted to them. Either steel or wooden stringers can be supported by the devices described herein.

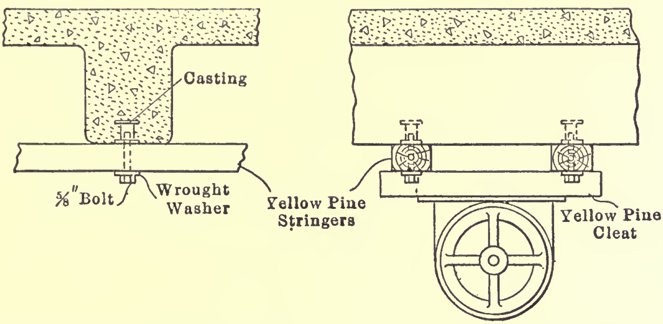


FIG. 1.—WOODEN STRINGERS SUPPORTED FROM SPOOL CASTING.

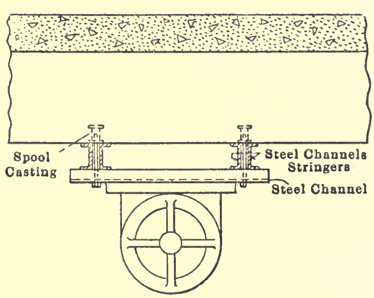


FIG. 2.—STRUCTURAL STEEL STRINGERS SUPPORTED FROM STEEL CASTING.

In the usual concrete building the ceiling is divided into bays by beams that extend down from its surface. Stringers are most often supported from the beams, as suggested in the illustrations, but are sometimes clamped to the floor slabs between beams. The initial step, then, in erecting a stringer is to arrange some method of attaching to the beams the bolts that are to support it. If foresight has been exercised, provision for supporting bolts will have been made during the erection of the building. Otherwise the installer must drill holes in the concrete to accommodate the bolts.

Figs. 3 and 4 show methods of attaching bolts to beams of concrete

buildings wherein no provision for bolts was made at the time the building was erected. It should be noted that in both of these examples 3/4-in. round stock is used for the holes. Bolts of smaller diameter are not

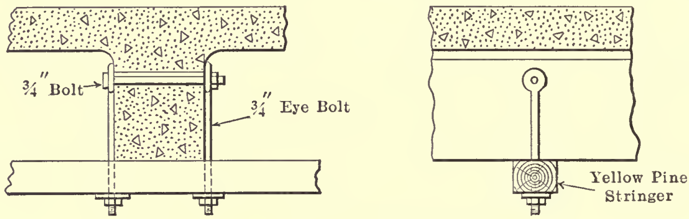


FIG. 3.—EYE-BOLT SUPPORTING STRINGERS.

trustworthy for supporting the loads ordinarily encountered in practice; also there is a possibility of a bolt smaller than 3/4 in. diameter being twisted asunder when a nut is tightened with a wrench in the hands of an

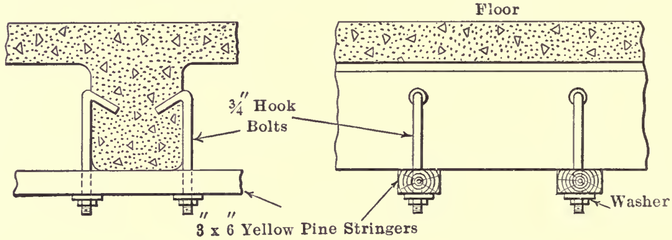


FIG. 4.—HOOK-BOLTS SUPPORTING STRINGERS.

able-bodied wireman. In Fig. 3 a horizontal hole is drilled through the beam and through it is passed an ordinary bolt which supports an eye-bolt on either side of the beam. The eye-bolts support the stringers.

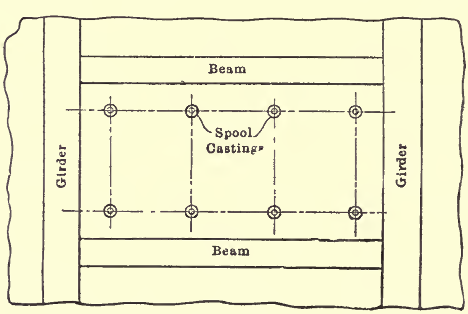


FIG. 5.—SPOOL CASTINGS IN CEILING.

Where one bolt will safely sustain the load an L-bolt, similar to that shown in Fig. 7, can be used instead of the through bolt and the two eye-bolts. In Fig. 4 slanting holes are drilled in the beam side, in which hook-bolts

engage. The hook-bolts are merely pieces of round stock threaded on one end and provided with a nut and bent to an angle of about 60 deg. to form a hook at the other.

In drilling holes in concrete an air drill or an electric drill will be found profitable if there is much drilling to be done. If such an investment is

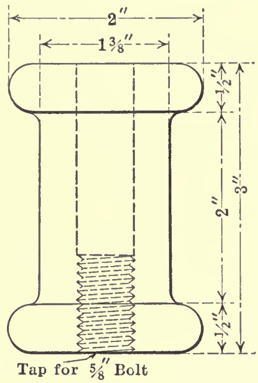


FIG. 6.—DETAILS OF SPOOL CASTING.

not justified, the ordinary rock drill (Fig. 8), which resembles a cold chisel except that it is longer and has a greater angle between faces at its cutting edge, is the best tool to use. Such a drill can be readily forged from tool-steel stock by a blacksmith and so tempered as to maintain its cutting edge for a maximum period. Note (Fig. 8) that the cutting edge of the drill is forged slightly wider than the stem to provide clearance. In

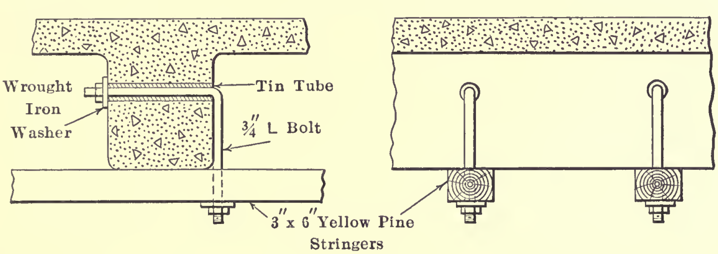


FIG. 7.—L-BOLT IN TIN TUBE HOLE.

using the drill its head is pounded with a hammer and the drill is turned a portion of a revolution between each blow to make the hole cylindrical and to prevent the drill from wedging in it.

In modern concrete industrial buildings, as above suggested, some provision is usually made during construction so that pipes for heating and sprinkler systems, shafting stringers and electrical conduits can be supported without its being necessary to drill the concrete after the building is completed. One method of making such provision is to cast in the concrete ceilings, as shown in Fig. 5, cast-iron spools such as that detailed in

Fig. 6. Where these spools are inserted stringers can be bolted to them, as shown in Figs. 1 and 2. These illustrations show the spools set in beams instead of in floor slabs. For stringers the beam location is preferable because with it an unbroken line of stringers can be erected the entire length of a building. Cutting of the stringers into lengths to fit the spaces between beams is avoided.

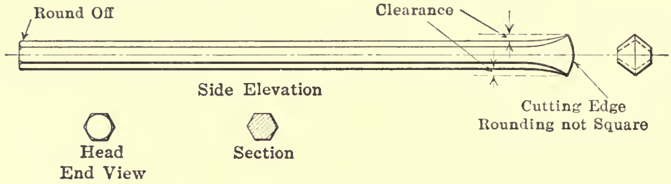


FIG. 8.—DRILL FOR CONCRETE.

Fig. 7 illustrates another method of preparing concrete beams for the reception of bolts. A sheet-iron tube is cast in the concrete at each location where a support point is desired; then the stringers to support a motor can be held by either an L-bolt (Fig. 7) or a through bolt and two eye-bolts, as in Fig. 3.

Repairing a Broken Motor Leg (By James F. Hobart).—During shipment the foot of a 30-hp. induction motor became broken as shown in

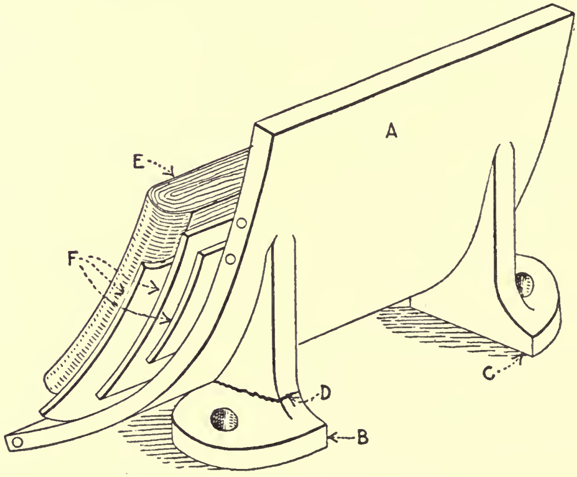


FIG. 1.—BREAK IN MOTOR FRAME.

Fig. 1. It was necessary to repair the break with the least possible delay and at the lowest cost. The foot being an isolated projecting member of considerable section, it was not necessary to provide for the expansion and contraction of other portions of the casting. The sole object was to heat the fracture without damaging the coils of the stator winding.

The outside of the motor casing is shown at *A; B* and *C* are the feet,

and the break to be repaired is visible at D. The field winding E was protected by placing between the coils and the shell casting several thicknesses of asbestos board which had previously been saturated with water. The several layers of asbestos which were packed into the space between the shell and the field winding are shown at F. The pieces were held in position by several small wooden wedges which were driven between the asbestos board and casing.

When the first attempt at welding was made excessive caution prevented adequate heating of the fractured parts, and only the surface of the break was welded. This weld was very promptly broken as soon as strain was placed upon the foot again.

The owner of the motor was told that a second attempt would not be made unless the motor foot could be treated exactly as though it were a bare casting with no windings in proximity to it. He assented but stationed one of his men beside the motor to inspect the field winding during the operation.

When the motor was in position above the forge, bricks were placed about the broken parts to keep the heat as much as possible from all other portions of shell. Pieces of asbestos board were freely used. After these precautions had been taken the foot was heated to a red heat. The welding was then completed as speedily as was possible. The asbestos apparently did its work well, for the coils were not damaged and the motor was placed in service.

Electric Welding of Broken Motor Shaft (By A. T. Sartoris).—The accompanying Fig. 1. makes clear a method of welding broken motor

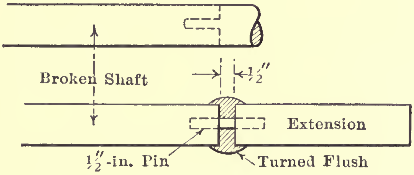


FIG. 1.—WELDING A BROKEN SHAFT.

shafts which has been in use at one plant for several years and results in a repair that is practically as strong as the original shaft. The broken section is first shaved off square and a hole drilled in the center to take a 1/2-in. steel pin. The shaft extension is meanwhile cut to proper length, allowing for the 1/2-in. kerf which is to be filled up with metal flowed on in making the weld. After the extension has been drilled the two parts are joined by the pin as shown, and with an electric arc additional metal is added around the joint until the shaft diameter is slightly exceeded. After making sure that a true weld has resulted, the surplus can be turned down, removing all traces of the repair.

Rebabbitting Motor Bearings (By C. R. McGahey).—The continuous operation of motors and generators depends very largely upon the care bestowed upon them, and this is especially so of small motors. Many of the latter are thrown out of commission because of lack of attendance or for the want of proper setting. This is not only true of direct-current motors, but also of alternating-current motors, the general impression

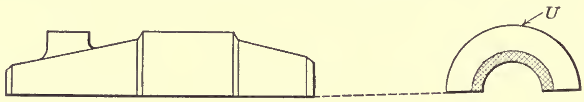


FIG. 1.—SOLID BEARING.

being that the latter require no care whatsoever. Where induction motors of the squirrel-cage type are set on some pieces of timber or on a vibrating foundation the vibration will cause the insulation to work out much more quickly and proper service thereafter is impossible. A good foundation is very essential for the reliable operation of motors. The care of bearings is also another important consideration, and the mere

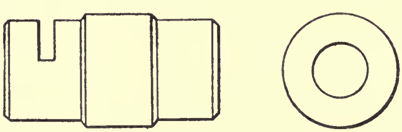
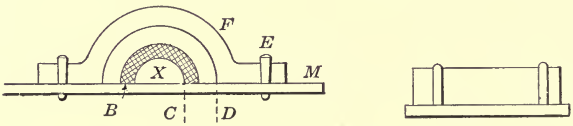


FIG. 2.—RENEWABLE BEARING.

fact that a motor bearing is working well to-day does not mean that it will be in the same working condition an hour hence. It is advisable where motors are used very much to carry a separate set of bearings in stock for each size of motor in operation, so that when the babbitt is melted or becomes loose it may be replaced without the necessity of shutting down the motor for any considerable length of time. Some motor



FIGS. 3 AND 4.—BEARING JIG AND ARBOR.

bearings have an iron shell lined with babbitt metal which is poured in place, while others have a finished babbitt liner. Fig. 1 shows a bearing of the former type, and such are very difficult to repair, especially if ring oilers are used. Fig. 2 shows a bearing in which the babbitt is merely slipped into place. A jig for rebabbitting bearings is shown in Fig. 3. This consists of a plate *M* on top of which is a yoke piece *F* bored out to

fit the bearing surface U (Fig. 1). An arbor X represents the diameter of the motor shaft. The distances C and D must be accurate, so that the bearing will fit when placed in the motor. The pins E serve to hold the housing in place while the babbitt metal is poured. In the engraving, Fig. 3, the babbitt metal is represented at B and a side view of the arbor is shown in Fig. 4. The latter shows the projecting rings to form the oil grooves. A jig of this kind will be found very useful for repairing separate motor bearings and a bearing such as that shown in Fig. 1 can also be repaired in this way, as the fitting forms the guide for the centering of the shell for the babbitt metal. Great care must be taken in the construction of the jig so that the babbitt lining will be true, otherwise it will not fit the shaft and will run hot.

Care of Electric Motors (By Wm. Kavanagh).—A good bellows will be found a very useful tool in keeping motors clean. Where several motors are in daily use an air line should be situated close to each motor, the line having a hose connection and stopcock handily located, for the

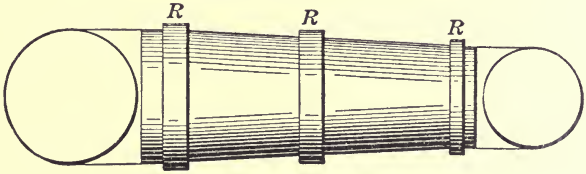


FIG. 1.—MANDREL FOR SHAPING OILING RINGS.

purpose of blowing off the accumulated dust around the fields, armature and brush connections. Air at high pressure should not be used because it is likely to fray the insulation or possibly blow it away entirely. A pressuie varying from 5 lb. to 10 lb. per square meter will be found sufficiently strong to blow off the dust and baked material, thus removing the liability of fire.

Whenever the oiling rings are out of true they will not rotate, thus causing a heated journal or bearing. Occasionally when oiling rings are being put in place they become dented or pressed out of "true," and of course when this occurs the rings must be pressed or hammered back to shape. A very handy tool enabling the rapid shaping of the rings is shown in Fig. 1. This is a tapered mandrel made out of a piece of hard wood or iron, the small end of the mandrel suiting rings having the smallest diameter, while rings of large size can be shaped on the larger end, as shown at RRR.

Fig. 2 illustrates another very handy tool, known as a "sandpaper block." Sometimes it is desirable to use a strip of sandpaper on the commutator to clean off foreign matter. With small motors it is sometimes difficult to do this, but by employing the sandpaper block as shown

it is a simple matter to clean any size of commutator effectively and without incurring the danger of shock. The block can be made of any size required and by wrapping the curved end with one or more strips of sandpaper the commutator can be cleaned as often as necessary. The sandpapeı may be held in position by means of a few thumb-tacks, and when worn it is easily removed and a new strip put in its place. It will be found advantageous to line the curved end of the block with a piece of

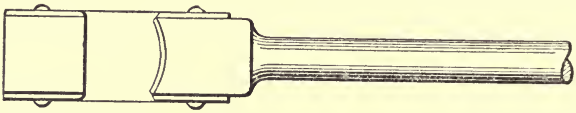


FIG. 2.—"SANDPAPER BLOCK" FOR CLEANING COMMUTATORS.

felt or thick cloth over which the sandpaper can be placed, the object being to have the sandpaper conform more closely to the shape of the commutator. Thus a slight pressure of the hand is all that is required to clean the commutator thoroughly. If possible, the curve of the block should always suit the curve of the commutator; when such is the case the entire surface of the commutator will receive an equal amount of sandpapering, which tends to maintain a true surface. When the brushes are not staggered the commutator tends to wear unevenly, but the correct use of this sandpaper block will offset the tendency almost entirely.

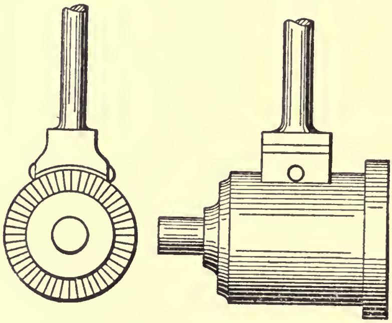
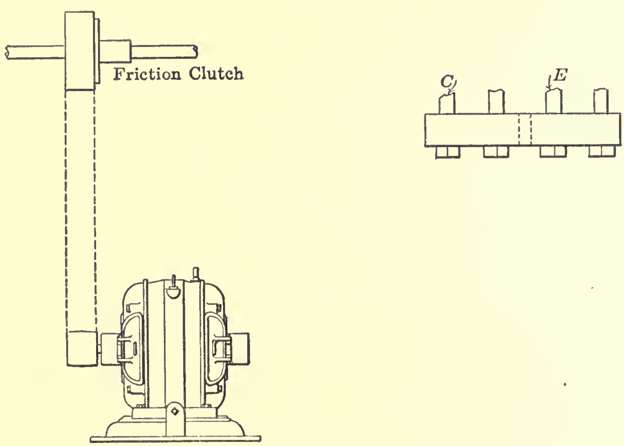


FIG. 3.—APPLICATION OF "SANDPAPER BLOCK."

Fig. 3 shows the application of this block to a commutator and illustrates how convenient it becomes for motors situated on ceilings or in other inaccessible places.

Troubles with Induction Motors (By C. R. McGahey).—Motors are frequently installed in manufacturing plants in such manner as to cause considerable trouble and annoyance, not to mention frequent shut-downs. Sometimes one finds an induction type of motor having a squirrel-cage rotor coupled so that it will be necessary for it to start under

heavy load. Aside from the injurious action of the excessive current upon the motor itself, this method of running an induction motor is detrimental to the life of the belt and the starting box, and causes much annoyance by the opening of circuit-breakers and the blowing of fuses. For instance, in the case of motors driving heavy shearing machinery, punches or devices carrying heavy balance wheels, these should first be placed into operation without load, so that the stored energy in the flywheels may be utilized when the load is thrown on. To start such machinery on the jump requires an excessive amount of energy and current oftentimes greater than that permitted by the insurance authorities for the size of wire used in feeding the motor. Many of these installations can be made to operate more satisfactorily, and require less energy at starting, by arranging the motor drive as shown in Fig. 1. Here a friction clutch is employed on the main lineshaft so that the motor may be brought up to speed before



FIGS. 1 AND 2.—TROUBLES WITH INDUCTION MOTORS.

it is connected to the load. The friction clutch permits the load to be picked up gradually while the motor is running at full speed. In selecting a friction clutch one should be certain that it possesses ample capacity. Not infrequently a clutch which has ample capacity at first will not carry its connected load after long service, so that it is best to purchase one slightly larger than would be absolutely necessary. It will then be found to require very little attention and give much better service than one operating up to its limit. The main feature which a friction clutch used in connection with an electric motor should possess is ample sleeve bearing, so that it will remain true and give a good contact without slippage. It is felt that if the suggestions above are heeded burn-outs at contact points in the starting box, such as shown in Fig. 2 at *C* and *E*, will be entirely avoided. The extra current which is required in a motor of the induction

type starting under full load from standstill is exceedingly detrimental to the life of contact points, regardless of the oil, and it is not long before trouble is experienced with the starting box. Unfortunately, owing to the simplicity of the induction motor, it is frequently run under unfair conditions, the most prevalent of which is that of throwing the motor on the line under load.

Starting Torque of Induction Motors (By M. O. Southworth).—Probably the most common mistake in the installation of induction motors is the selection of a motor that is too small to start the load. Most machinery manufacturers can now give us fairly reliable data as to the power required to drive their machinery under running conditions, but few of them know what starting torque is required to start the load from rest and bring it up to speed. Some classes of machinery, such as fans and centrifugal pumps, require little effort at starting, but the load accumulates as the speed increases—other classes of machinery require practically the same effort at starting that they do to maintain their speed after in motion and some even more than this. In the latter class are pumps and air compressors starting under pressure. Elevators and hoists or other machinery that move a dead weight or pull against a fixed constant resistance and often a line shaft with many idle belts will be found to belong to the class that requires more effort at starting than after it is in motion and driving full load.

This is often the controlling feature in selecting a suitable induction motor, for while modern motors will exert a starting effort considerably greater than that corresponding to their rated horse-power, they are often found connected to loads that they will run easily after starting, but will fail to start without assistance. Very often this is due to a drop in voltage at the motor terminals on account of insufficient transformer equipment or a long supply circuit of insufficient size. This condition is readily discovered by a voltmeter, but even then the question often arises as to whether the motor is large enough if the voltage were properly maintained or how large a motor should be used. The positive determination of this matter is so simple that it is surprising the subject is so often a matter of controversy. The method of procedure in typical cases given below is presented in the hope that resort to these simple and convincing tests will in a measure eliminate the fruitless argument that often results in such cases. Suppose an induction motor is belted to a line shaft which may drive a group of machines or a single machine through other belts, as shown in Fig. 1 It is found that the motor fails to start this load and the question arises whether the load is greater than the motor should be expected to start or whether the motor is at fault. The driven machinery may be connected or not, but with this we are not concerned, as it is the actual torque that the motor has to exert under starting conditions that

is to be the subject of test. There is always some slack in the connecting belts and when the motor is started it first turns the line shaft slightly, taking up this slack, and then the full starting effort necessary to overcome the resistance of the belts and the idle pulleys will be required.

If the pounds pull the driving belt has to exert to start this shaft and machinery can be found this can easily be translated into horse-power by considering it in connection with the belt speed after the motor is running, and to find this pull one can proceed as indicated in Fig. 1. A clamp which may be made of two pieces of hard wood slightly wider than

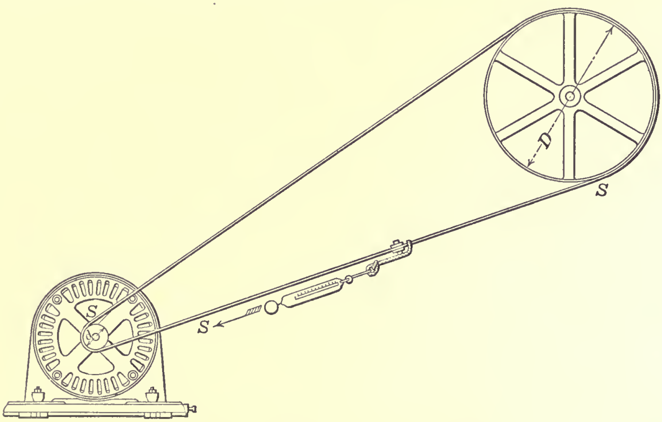


FIG. 1.—DETERMINING BELT PULL.

the belt, with bolts passing through each end, is fastened to the pulling side of the belt and by means of a rope fastened in a loop around the belt back of this clamp or otherwise attached to the clamp an ordinary spring balance is fastened to the belt, as shown in Fig. 1. In the case of a small motor, the clamp may often be omitted and the rope simply tied around the belt. Now, holding this balance parallel to the belt and pulling in the direction that the belt runs, first take up the slack of the driving belts and then a further pull will start the shaft and the maximum reading of the scale will indicate the number of pounds of useful belt pull required to start the load. From the number of revolutions and the size of the pulleys we find the belt speed in feet per minute and multiplying this by the pounds pull, we have the number of foot-pounds per minute, which, divided by 33,000, give us the horse-power of the motor which will exert this starting effort without overload. For example: Suppose a pull of 60 lb. is registered on the spring balance and the driven pulley on the line shaft is 36 in., or 3 ft., in diameter, and runs at 200 r.p.m., the horse-power would be: H.p. $=60 \times 3 \times 3.14 \times 200 \div 33{,}000 = 3.12$.

Most modern motors will exert a starting torque about 50 per cent. greater than the torque corresponding to their full rated load when full

voltage is impressed at their terminals, but it is often undesirable to apply full voltage on account of the heavy current that will be drawn from the line. Hence this excess should be used only as a margin for emergencies. With large motors it is better practice to arrange the load so that it may be disconnected at the start and not over 30 per cent. to 50 per cent. of full-load synchronous torque be required.

In Fig. 2 is shown the method for testing a motor directly connected to an elevator or other machine that may be driven by a coupling. A bar of iron or wood of convenient length is clamped beneath the heads of the coupling bolts or may be simply hooked in place between the bolts and shaft in such a way that it serves to move the motor and driven machine in the normal direction. The motor is turned until all the backlash is taken out and it actually begins to raise the load, then a spring balance is applied at a fixed distance "L" from the center of the shaft and the pull on the balance would indicate the effort required to start the load as in the

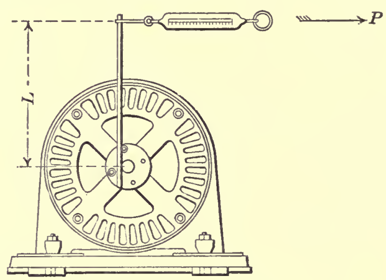


FIG. 2.—TESTING MOTOR.

case of the belt. Care must be taken to pull in a direction at right angles to the line from the center of the shaft to the point where the balance is attached to the lever and to measure the distance from the center of the shaft to that point. Then the horse-power is obtained by the formula: H.p. $=6.28$ N.L.P. $\div 33{,}000$ in which P equals number of pounds pull shown by the balance, L the distance from the center of shaft to the balance, in feet, and N the number of revolutions of the motor per minute. In the case of a pump or other machine driven by gearing, the spring balance may be attached to the rim of the gear and pulled in a tangential direction, and the horse-power obtained by multiplying the pull by the speed of the gear in feet per minute and dividing by 33,000. This test may also be used to determine in advance the horse-power required to drive an elevator or similar machine before the installation of a motor. It is, of course, not applicable for this purpose when the load is of such character that the torque increases with the speed, but is perfectly reliable and accurate in all cases for determining the starting effort.

Turning down a Commutator (By J. Cloyd Downs).—The following

scheme for turning down a commutator may be new to some and has been used in a number of instances with very satisfactory results. The method usually used to turn down a commutator on a repair job where the armature is too large to remove is to leave one or two pairs of brush arms on and run the machine from these at as low a speed as the field regulation will permit, or possibly with a water rheostat in the armature circuit. Of course, this will do where nothing else is possible, but there is always bad sparking and burning at the point of the cutting tool due to its short-circuiting the bars when it crosses the mica. The tool has to be sharpened frequently and the job is seldom good even where the greatest care is exercised. For this reason it is always best to belt the machine to a separate motor and turn down the commutator with the fields unexcited. In the plant with which the writer is connected there are several machines

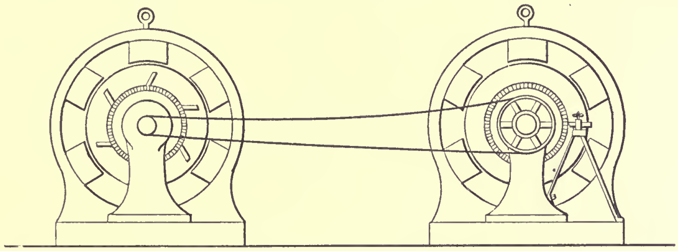


FIG. 1.—TURNING DOWN A COMMUTATOR.

set symmetrically with their shafts parallel. The shafts overhang the outside of the bearings sufficiently to enable one to put a pulley on the shaft of the machine to be repaired. The belt is then put directly on the shaft of the other machine and by using a suitable pulley the proper speed for turning down is obtained. A commutator 20 in. or slightly more in diameter can be run at about 75 r.p.m. with good results, but it is better to keep below this speed than to exceed it. The accompanying Fig. 1 shows this scheme very plainly. It is unnecessary, of course, to shut down the machine used as the motor and the additional load would seldom if ever, be of serious moment.

Adjusting Interpole Fields of Generator (By H. M. Nichols).—The following method of adjusting the interpole fields of generators may be of interest to those who operate this class of apparatus. First set the brushes on no load neutral by taking voltage readings with the armature rotating clockwise and then counter-clockwise. The brushes will be on the neutral point when the two voltage readings are the same. Then throw the rated load on the generator and adjust the interpole field strength until the neutral point is brought back to the no-load neutral position, this being determined by taking voltage readings with the generator rotating in both directions. The interpole field strength is now properly adjusted

for all loads up to the saturation of the interpoles and a permanent shunt of German silver should be made up for the interpole field winding.

Wiring Equipment for Motor Testing (By H. S. Travis).—It is often desirable to test motors that are already installed in order to ascertain the power required for certain operations or to find whether a larger or smaller one than the one operating will best satisfy the existing conditions. In making such tests usually the most expensive and tedious portion of the work is to connect the measuring instruments into the motor circuit. This is particularly true where the motor is one of large capacity having large conductors. If motors are tested frequently both time and money are saved by the use of portable wiring equipment by means of which testing instruments can be quickly and effectively inserted in the motor circuits.

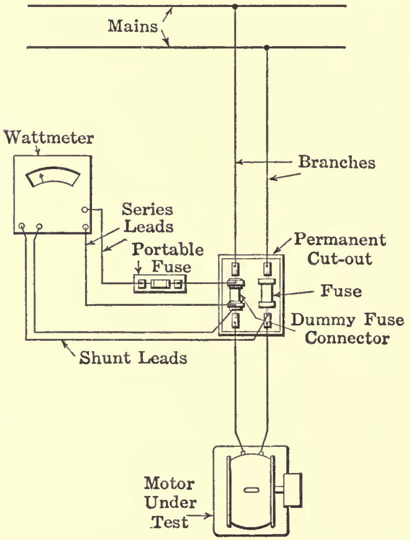


FIG. 1.—CONNECTIONS FOR MOTOR TESTING.

Fig. 1 shows the application of such a device. With it instruments can be connected into the motor circuits without disturbing the permanent wiring. In the engraving a direct-current motor is shown, but the scheme is quite applicable to three-phase motors. Two dummy fuse connectors will be required for three-phase testing, whereas only one is required in direct-current tests. Referring to Fig. 1: Instead of disconnecting one of the leads to the motor in order to cut in the series coils of the wattmeter, the connection is arranged at the fusible cut-out. Nearly all motors are protected with a cut-out of this type. One of the fuses is removed from the cut-out and in its stead is inserted a dummy-fuse-connector like that detailed in Fig. 2. The leads to the wattmeter are connected—frequently permanently—to the binding posts of the connector.

There is no path directly through the connector because the old fuse from which it is made has been taken apart and all portions of the fusible conductor that it contained have been removed. The circuit to the motor must, therefore, be completed through the wattmeter.

The details of Fig. 2 show how the connector is made. Connecting straps (see Fig. 3) are soldered to the ferrules of what was the fuse. The terminals are arranged by soldering on each connecting strap a nut (see Figs. 2 and 3) into which a brass machine screw turns. Wattmeter leads

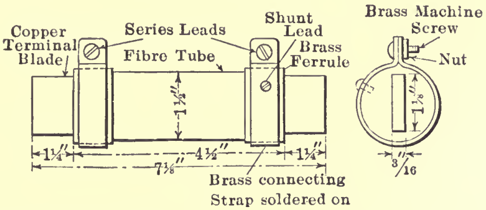


FIG. 2.—CONNECTING STRAPS ON 101–200 AMP. FUSE.

are either permanently clamped under the heads of the brass machine screws or soldered into lugs of the form shown in Fig. 4. The nut should preferably be of brass, as it can be soldered more easily; but an iron nut will do. In soldering iron the metal must first be filed so that a clean, new surface will be presented and then tinned, using ammonium chloride (sal-ammoniac)—in crystalline or powdered form—as a flux, before an attempt is made to solder it to another metal. After the straps are affixed to the ferrules of the old fuse a hole for a small machine screw is drilled

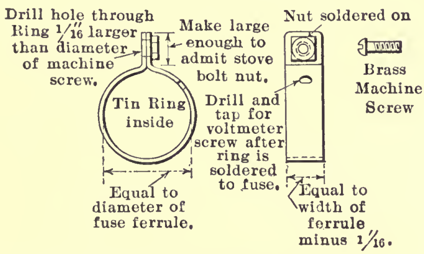


FIG. 3.—DETAILS OF CONNECTING STRAP.

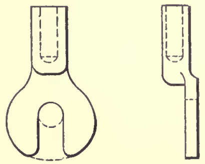


FIG. 4.—LUGS FOR CURRENT LEADS.

and tapped in one of them, as indicated in Fig. 2. This provides means for connecting one of the voltage leads to the wattmeter. Although Fig. 2 only shows a connector for 101–200-amp. National Electrical Code fuse holders, connectors for the other size code holders can be arranged in essentially the same way. All of the directions given on Fig. 3 are general and apply to all sizes of knife-blade contact fuses.

Where connectors are to be made from ferrule contact fuses—those

of capacities under 61 amp.—it is best to solder the wattmeter leads directly to the ferrules. Conductors necessary for the relatively small currents involved will be so small that they will not be difficult to handle and there would be no advantage in being able to disconnect them at the ferrules.

The lug shown in Fig. 4, which may be used on the dummy-fuse-connector ends of the wattmeter leads, is made from an ordinary lug by filing out the portion enclosed within the dotted lines in the figure. The advantage of this type of "forked" lug is that it may be inserted under a machine screw head on the connector, without removing the screw entirely from its hole. Time is thus saved and the possibility of the screw becoming lost is avoided.

Referring again to Fig. 1: A portable fuse is often inserted in the circuit leg that contains the dummy-fuse-connector so that the motor and instruments will be protected while the test is being made. Such a fuse is not always cut in; it is, however, safer to do so.

Provision is made on the connector for the attachment of one voltmeter lead. The other lead can be connected to its side of the circuit by inserting its thin metal terminal lug or its bared end between the fuse knife-blade and the corresponding contact clip.

Testing Polarity of Field Coils (By E. R. Shepard).—In testing the polarity of the poles of an alternator an ordinary carbon-filament lamp

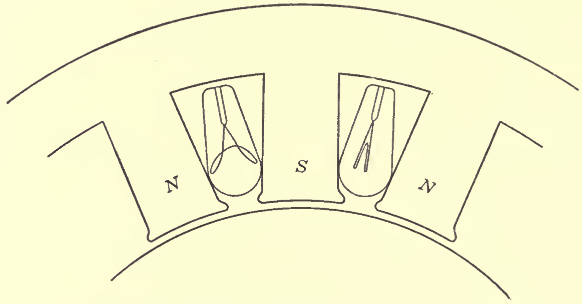


FIG. 1.—FILAMENT POSITION UNDER FLUX ACTION.

carrying a direct current was found to give very striking and definite results. By placing the lamp in the region of the leakage flux between adjacent pole tips the two loops of the filament will separate widely or draw close together, depending on the direction of the flux. By progressing around the fields with a lamp in this manner a reversed pole or a dead pole can be instantly detected. The behavior of the lamp is indicated as shown in Fig. 1.

Testing Magnet Coils for Short-circuits (By L. J. Todd).—The scheme used at the repair shops of the Cincinnati Traction Company to

test motor-field and other coils for short-circuited turns consists in linking the open coil with a magnetized iron core, as shown in Fig. 1, in this way forming of the suspected coil a transformer secondary. Local currents will then flow in any short-circuited turns, and the existence of these faults will be indicated by the increased current taken by the core-magnetizing windings, as well as by the development of heat in the coils themselves.

The sketch shows the construction of the three-pole laminated-steel core used. The keeper with which the magnetic circuit is completed is

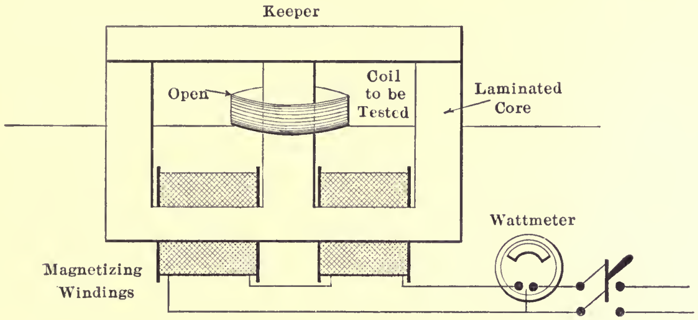


FIG. 1.—DIAGRAM OF CONNECTIONS.

made removable, its weight alone when in position holding it in ample contact with the planed surfaces of the leg laminations. By experiment the exciting energy taken by the core alone or with an open-circuit coil is known from previous determinations. Then if, with a suspected coil under test, the wattmeter indicates an amount in excess of this value, the faulty coil is left in place on the core until the short-circuited windings reveal themselves by heating. In this way the fault can be accurately located and repaired.

Commutator Testing Device (By F. B. Hays).—The accompanying drawings show a device for testing magneto commutators installed by the Hercules Electric Company. It is a great time-saver as compared with other methods in general use and is at the same time simple to operate and absolutely dependable. At the Hercules company's works a boy operating the device tested over 6000 commutators in one ten-hour day.

A plan view and side elevation of the machine are shown in Fig. 1, in which *A* is the bin for commutators that are to be tested, *B* the bin for those that have been tested and have been found all right, *C* the contact brushes carrying the current for testing each commutator, and *D* the bull's-eye lamps which indicate short-circuits and grounds in the commutators.

The method of testing is as follows: The operator places a commu-

tator from bin *A* horizontally on the contact brushes *C* in such a manner that each end of each segment rests on a brush while the center of the commutator rests on brush No. 1. Behind each brush is a helical spring which presses the brush upward, thus insuring perfect contact between

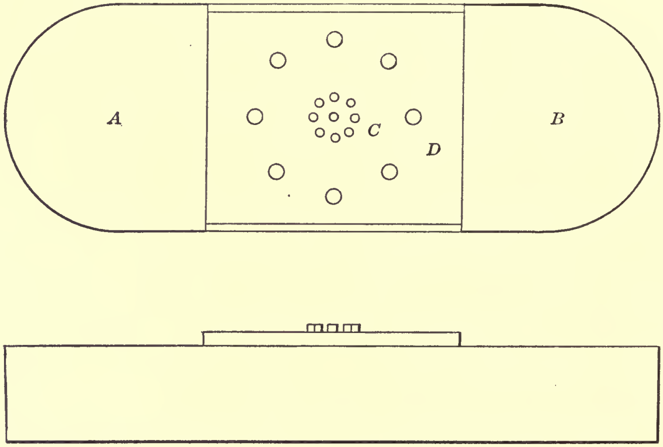


FIG. 1.—COMMUTATOR TESTING DEVICE.

the brushes and the commutator segments. If a short-circuit exists between two of the segments, the two bull's-eye lamps opposite the segments will show a dim light. If the commutator is grounded, a single bright light will show.

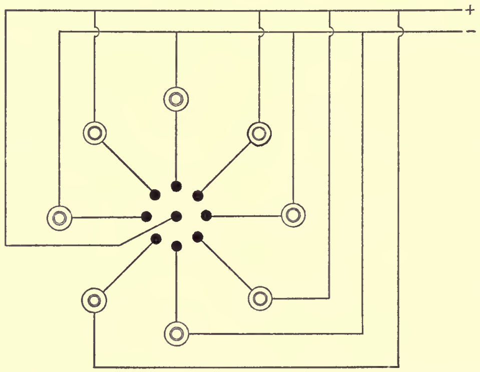


FIG. 2.—DIAGRAM SHOWING CONNECTIONS OF COMMUTATOR TESTING DEVICE.

Fig. 2 is a wiring diagram for the device. A short study of this diagram will make the principle upon which the device operates perfectly clear. It will be noted that it is necessary to rotate the commutators through an arc of only one segment to test all segments for "a ground."

Testing Armatures with Alternating Current (By E. W. Copeland).—While the usual method of testing between adjacent commutator bars with a millivolt meter will indicate short-circuited or poorly soldered leads by a low reading and open-circuited or poorly soldered leads by a high one, it often occurs that an armature is reinstalled with considerable time and labor and found to be defective after all. The millivolt or drop method merely measures the resistance of each coil, but when an armature is subjected to magnetic induction an e.m.f. is induced in its winding which will cause current to flow in the turns that are short-circuited. Very often one turn in a coil is forced so hard against another that the insulation is broken and the turns become short-circuited. In such a case the millivolt test might not serve to detect the short-circuit, and as a consequence

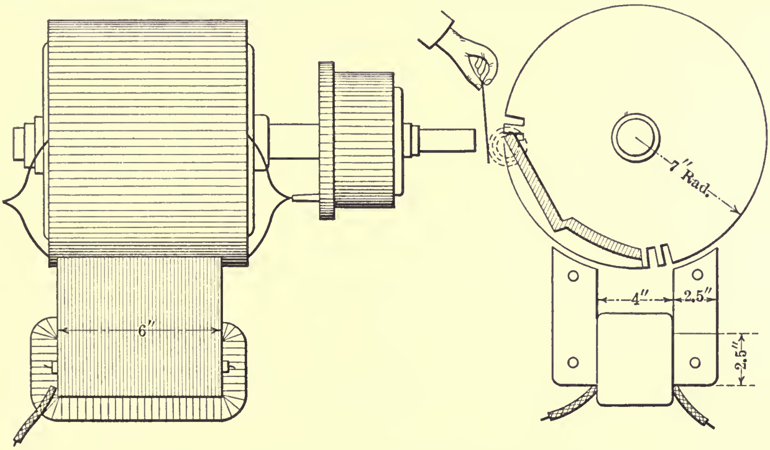


FIG. 1.—METHOD FOR TESTING ARMATURES.

the turns, and probably the coil, would be destroyed by the immense current which would flow in the short-circuited turns when running in the magnetic field of the machine.

A simple method to detect such defects more readily requires alternating current, whereby an alternating flux is produced by a U-shaped magnet made of sheet iron, laminated as shown in Fig. 1. When an alternating flux flows through an armature coil as shown an e.m.f. is produced which will cause current to flow in any turns that are short-circuited. This current will set up a strong magnetic flux around the coil, and if a piece of sheet iron is held near it will vibrate very rapidly. The coil will also heat very rapidly, and if the magnet is large enough for the armature that is being tested the coil can be burned out completely. This method will not only detect coils short-circuited in themselves, but will detect one coil short-circuited with another, as well as reversed coils. Open-circuited coils can be located by touching adjacent commutator bars

with a piece of wire. If the coil is all right a distinct spark will be noticed, but if it is open there will be none at all. The view Fig. 1, represents a four-pole armature and for simplicity's sake only one coil. When all the coils are in place if the armature is revolved slowly, holding the piece of sheet iron over the side of the armature as shown, each coil will be influenced and tested consecutively. Of course, the magnet will work equally well on any armature within its range of sizes. A magnet—or, more properly, a transformer—the size of the one shown to be used on 104 volts, 60 cycles, will serve for many size armatures. It is wound with sixty turns of No. 6 magnet wire. When using this magnet it should be fastened under the armature and the armature also fastened so that the core of the armature and that of the transformer have clearance enough for the armature to be revolved without touching the transformer core. The current should always be off while placing the transformer, as well as when it is not in use.

Method of Locating Grounds in Armatures.—It is often very difficult to locate a low-resistance or "dead ground" in a low-voltage armature

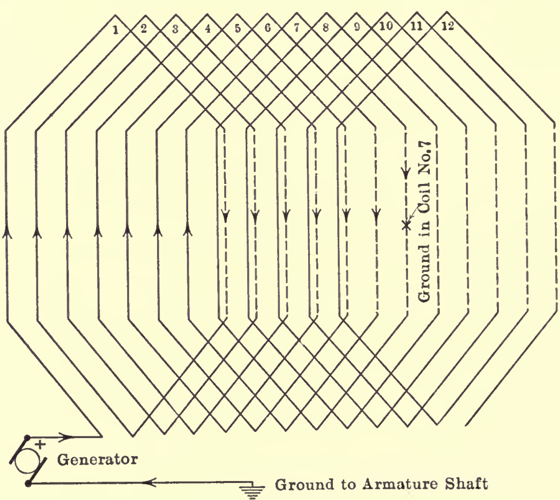


FIG. 1.—LOCATING GROUNDS IN ARMATURES.

owing to the very low resistance of the windings themselves. In such cases, however, the following method can be employed with very good success:

First, short-circuit all commutator bars by winding several turns of bare copper wire around them; then apply a source of energy, direct current preferred, to the commutator and shaft. The voltage to be used depends upon the resistance of the "ground."

This produces a circuit from the commutator through the grounded

coil to the ground and out through the shaft, thus setting up a field around the conductors in this coil. By applying a small piece of iron to the surface of the armature core and gradually moving it around, one can readily locate the grounded coil by means of its field, which attracts the iron.

The same method can also be applied to alternating-current apparatus, although not quite so readily. For example, in the case of a three-phase, single-circuit, Y-connected armature, first disconnect the Y, splitting the winding up into three separate circuits. Then test out each circuit with a magneto or some similar source with which the ground can be located.

Next apply a current to one end of the grounded circuit and to the shaft. Assume that there are twelve coils in this circuit, coil No. 7 being the grounded coil, while coil No. 1 is connected to the line as shown in the accompanying sketch, page 252.

There will then be a circuit through coils Nos. 1, 2, 3, 4, 5, 6 and 7 which can be readily detected with a piece of iron as previously explained, while coils Nos. 8, 9, 10, 11 and 12 are dead.

It is then, of course, obvious that if coils 1, 2, 3, 4, 5, 6 and 7 carry a current while coils 8, 9, 10, 11 and 12 carry no current, the ground must be in some section of coil No. 7, the circuit being completed at this point.

Remedying Trouble Caused by Varying Voltage.—Motors are often operated from street railway circuits on which there is a wide variation in voltage during the day. In one case a compound motor, rated normally at 550 volts, was used to drive a centrifugal pump taking water from a deep well to augment the water supply of a city. There was a variation of about 100 volts from the highest to the lowest voltage during the day at the panel controlling the motor. This caused the motor to run above normal speed on the higher voltage, and as the load on the pump corresponding to this speed was too large for the motor to carry, trouble was constantly experienced from the opening of the circuit-breakers. The load on a centrifugal pump under constant head is of such a character that a slight increase in the speed of the pump causes a large increase in the load on the motor. After making tests it was decided to increase the number of turns in the series field coils so that when the motor was running at normal voltage, and consequently at normal speed, more of the excitation would be supplied by the series field coils than formerly, and by placing a rheostat in the shunt field circuit, the excitation from the shunt coils was decreased, the total excitation remaining the same as before at normal voltage. When the higher voltage occurs the increased current has a greater effect on the field than before, owing to the greatest number of series turns, and the speed is not increased enough to change the load materially.

Conversion of 550-volt Generator to Edison Three-wire Service (By J. H. Bradbury, Jr.).—The generating station of the Topeka (Kan.)

Edison Company produces 550-volt direct current for the local railway as well as 110–220-volt Edison three-wire service for its own customers. The accompanying Fig. 1 shows how J. I. Chase, engineer in charge, has arranged switches in the circuits of one of his 500-kw., 550-volt engine-driven railway generators, making this machine available for 220-volt operation. The series compensating coil is first short-circuited by closing a switch in the base of the machine, while opening another switch, on the generator panel, introduces a prearranged, fixed resistance into the field circuit, reducing the excitation to the value where 220 volts will be developed. Closer adjustment is made with the field rheostat as

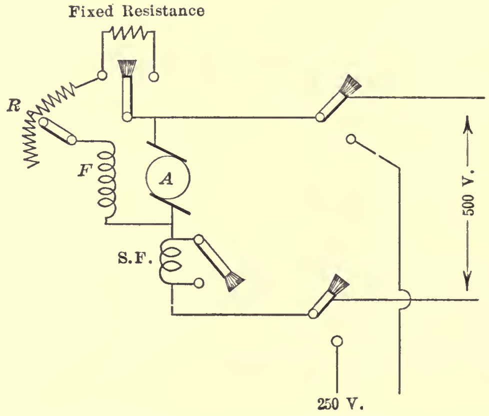


FIG. 1.—CONVERTING 550-VOLT GENERATOR TO 220-VOLT SERVICE.

before. At the rear of the board are disconnect switches for throwing the machine leads from the 500-volt to the 220-volt bases. At 550 volts the generator is rated to deliver only 830 amp., but no difficulty is found in taking currents as large as 1000 amp. at 220 volts, and the operation of the unit has proved most satisfactory under the converted conditions besides adding nearly 250 kw. to the 220-volt capacity of the station.

110-volt Shunt Motor on a 220-volt, Three-wire Circuit (By John Burns).—A friend of mine recently asked my advice about the cost of having his 2–h.p., 110-volt shunt motor rewound for 220 volts, as the central-station company refused to allow him to continue operating his machine across only one side of its Edison three-wire system, claiming that its operation tended to unbalance the lines. The cost of reconstruction as estimated by a local electrical company really exceeded the second-hand value of the motor, which was an old one; and as the service it rendered was only occasional and at slow speeds, such a change did not seem worth while. After examining the case, it occurred to me that at the low speeds commonly employed (control being secured by manipulating the starting

rheostat in the armature circuit) the current taken by the armature probably would not much exceed that taken by the field, and the two might accordingly be connected in series across the 110–220-volt, three-wire system with the neutral tapped in without much unbalancing. I tried this, first taking the precaution of reversing the armature brush leads to secure the same direction of motor rotation. The motor started up as usual, and at none of the loads it was called upon to pull did the armature circuit take current exceeding that of the field winding by more

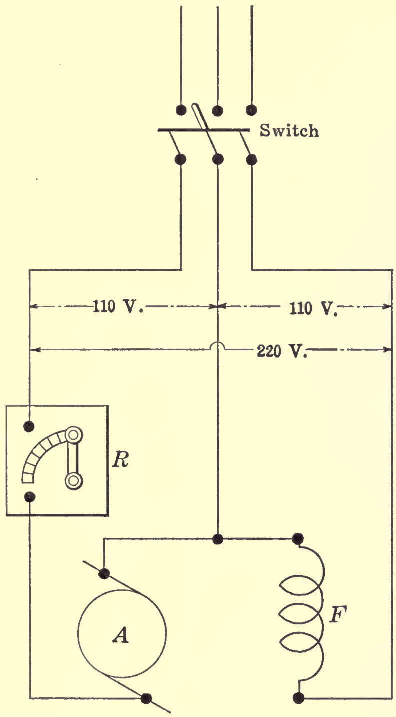
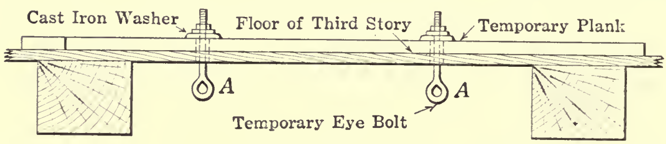


FIG. 1.—DIAGRAM OF MOTOR CONNECTIONS.

than the demand of a 32-c.p. carbon-filament lamp. When this fact was shown to the company's inspector, he, of course, was satisfied, as the unbalancing now produced by the motor did not exceed the effect of turning on a single lamp. This 110-volt motor accordingly is now running with its armature and field virtually in series across 220 volts, the neutral being connected in to carry the difference in demand of the two windings, and the expense of rebuilding it has been avoided by a few simple changes in connections. The arrangment is shown in Fig. 1.

A Method of Raising Inverted Motors (By H. T. Boynton).—There are many methods of raising an inverted motor to a location on a ceiling.

The one outlined herein will be found excellent under certain conditions. Fig. 1 shows how the tackle is arranged and Fig. 2 illustrates a plan view at the second floor. In the method described here the inverted motor is raised with two ropes. Each passes through a foundation-bolt hole in the bed-plate, is arranged around the motor frame and is made fast in



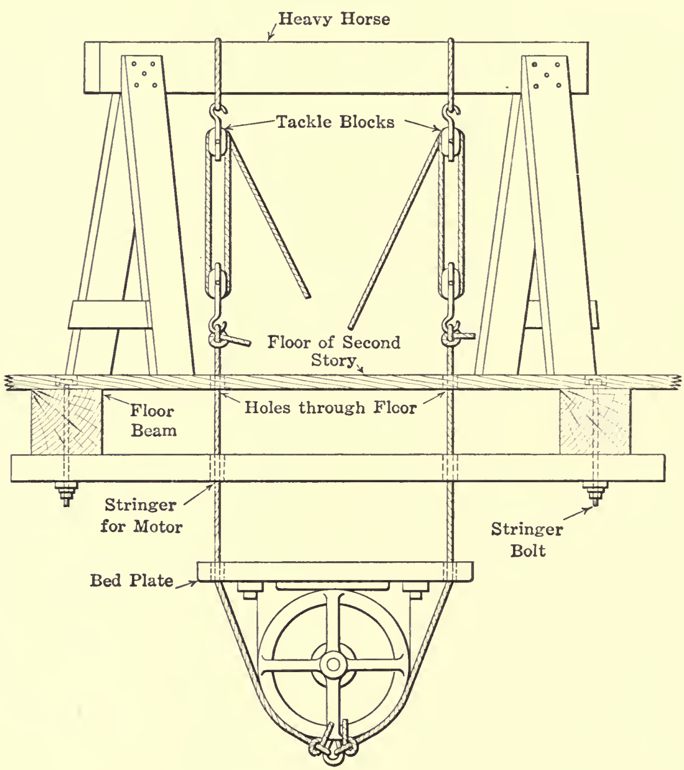


FIG. 1.—SIDE ELEVATION OF HOISTING OUTFIT.

the eye-bolt at what is normally the top of the motor. The two holes in the bed-plate through which the hoisting ropes pass are located at diagonally opposite corners. The hoisting ropes, after being made fast to the motor, are threaded through two of the four holes which have been bored to accommodate the bolts in the stringer pieces which will support the motor. Then the ropes are carried through two accurately located

holes in the floor above. On this floor rests a horse which supports the two sets of blocks with which the motor is raised. As indicated in Fig. 2, the horse is arranged diagonally so that it is directly over the two holes in the floor through which the hoisting ropes pass. Sometimes instead of

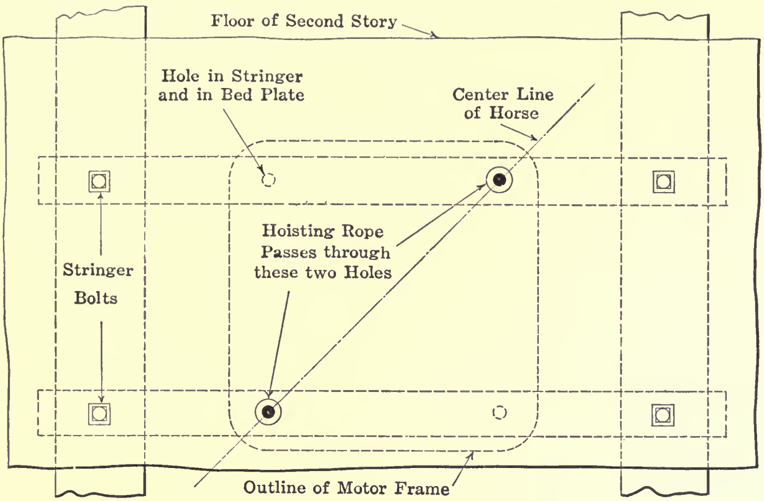


FIG. 2.—PLAN VIEW ON SECOND FLOOR.

using a horse to support the tackle, it is best to arrange temporary eye-bolts in the floor of the story next above as shown at A and A. They can be readily removed when the motor has been raised, but can be quickly replaced when the motor must be replaced or taken down. After a motor

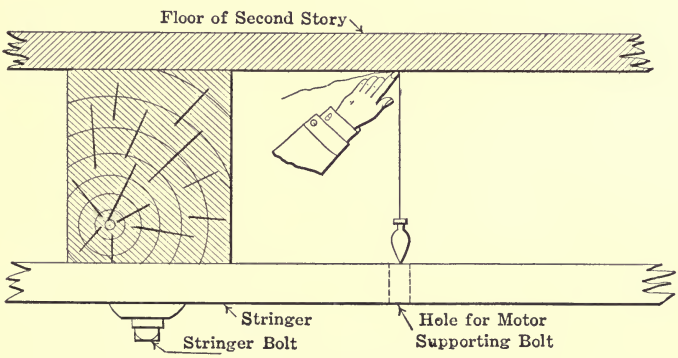


FIG. 3.—METHOD OF LOCATING BOLT HOLES.

has been raised to its position on the stringer planks two bolts are inserted through the open holes and set up tightly. Then the hoisting ropes are pulled out and the other two bolts are inserted. It should be noted that with this method it is not necessary to cut any large holes in floors.

The stringer pieces having been bolted to the beams, the four holes, two in each stringer, for the four motor-supporting bolts are located and bored in them. These holes should be at least 1/8 in. greater in diameter than the diameter of the supporting bolts. Then the two holes for the ropes are bored through the floor above. If a bit long enough is available this is easily done by using the holes in the stringers as guides and boring with the lower end of the bit through one of them. If no long bit is at hand the locations of the floor holes can be accurately determined with a plumb-bob, as shown in Fig. 3. The floor holes should be generously large so that they will not bind the hoisting rope. When buying a motor for inverted ceiling mounting or for mounting in any position, one should be selected which has a single bed-plate instead of two slide-rails. It is much more difficult and tedious, therefore expensive, to line up and level two slide-rails than one bed-plate. Furthermore, the slide-rails will require at least twice as many supporting bolts as will the bed-plate.

A Safety Panel for Cranes (By F. L. Thorne).—In an endeavor to prevent the accidents which continually occur through careless handling of cranes in a large mill the following control panel has been designed to

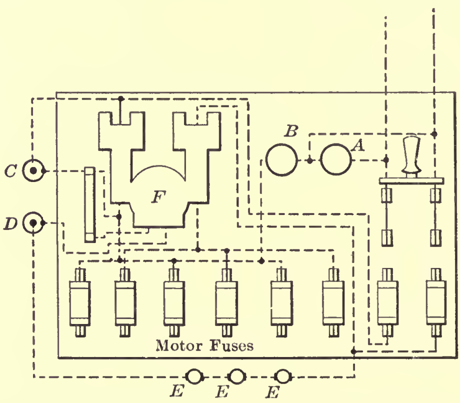


FIG. 1.—DIAGRAM OF CONNECTIONS FOR SAFETY PANEL.

replace the usual panel furnished in the cage of a bridge crane. It is intended to prevent such accidents as are caused by the operation of the cranes by unauthorized persons, by the unintentional or accidental manipulation of a controller while some person is working on or about the crane under the impression that it will not be operated, by a "dead" supply becoming "alive" while a controller may be in an "on" position with no one in the cage, and by various other unexpected conditions. It has become absolutely necessary not to rely on the operator or others whose duties require them to be about the cranes if it can be avoided. Fig. 1 is a diagram of the connections of the panel and Fig. 2 a front view of the

panel as mounted in its box in the crane cage. The main service switch is provided principally to satisfy the insurance requirements, and as it is present it has been considered advisable to provide the opening in the panel-box door, through which it may be operated, as an additional means of opening the main circuit in case of emergency. All ordinary main-line control is by the push buttons *C* and *D* operating the magnetic switch *F*, *C* being used to close and *D* to open the switch, as indicated in the diagram. It will be seen that the operating coil of this switch is so connected that when the switch is open the coil circuit is open. As the switch is held closed by the energized coil, any break in the coil circuit or failure of

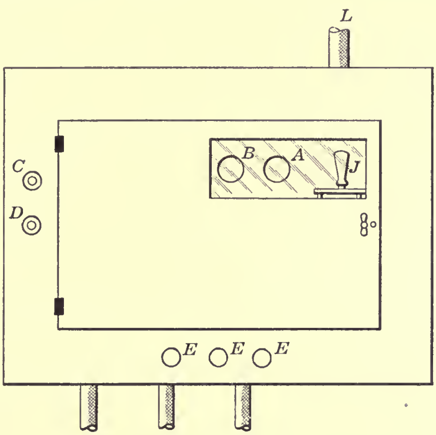


FIG. 2.—FRONT VIEW OF PANEL.

voltage therein will allow the switch to open. As long as there is no voltage in the main circuit the switch will remain inoperative, but if the main circuit is alive the switch may be closed by pushing button *C*, which shunts the break due to the switch being open. Button *D* being pushed opens the coil circuit and allows the switch to open. If any of the safety plugs *E* be removed the switch must remain open until they are returned, as their absence opens the circuit and the switch cannot be operated. The object of the plugs *E* is that anyone having one of these plugs in his possession may be assured that the crane is inoperative until he replaces it. The lamp *A* indicates by its incandescence that the trolleys are alive, and the lamp *B* indicates in like manner that the panel is alive on the load side of the magnetic switch. Fig. 2 illustrates the appearance of the completed panel box as mounted in the crane cage. The box is of sheet steel following standard panel-box construction with the exception of depth, which is made great enough to accommodate the magnetic switch. The door is locked and control of this magnetic switch is had by the push buttons before mentioned, which are mounted at one side of the door.

The window in the door is designed to allow the indicating lamps to be seen and the handle of the service switch to be reached. Other parts of the panel are inaccessible to any one but the electrician who carries the key. The three plugs *E* have a round-knob head painted bright red and on the door above, with an arrow pointing to them, is a notice directing any person working on the crane to remove and keep in his possession one of these plugs until his work is completed and he is leaving the crane, and all employees whose work brings them on or about the cranes are personally instructed to the same effect. Three plugs are considered sufficient, but, of course, more can be added if thought necessary. Suppose that an electrician and a machinist are sent to work on a crane, the crane runway or some other apparatus where the crane might interfere with them. One arrives and removes a plug, puts it in his pocket and goes to work. Soon the other arrives and in turn takes possession of another plug. At the completion of his work each one replaces his plug. From the time the first plug is removed until the last is replaced the crane cannot be operated. In this way it is hoped in the future to avoid accidents due to carelessness and definitely to place the responsibility for any such as may occur.

Methods of Mounting Motors on Side Walls and Columns (By H. F. Bearnes).—In wooden buildings motors of moderate output can be

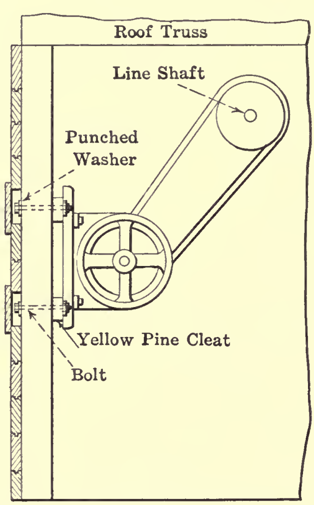


FIG. 1.—MOTOR MOUNTED ON CLEATS AT SIDE WALL.

mounted on the side walls as shown in Fig. 1. Substantial cleats, preferably of yellow pine, are bolted to wall posts and the bed-plate of the motor is bolted to these. Lag screws should not be used (unless many can be driven in) because, although they may appear to be quite firm

when inserted, the vibration of the motor tends to loosen them and they may pull out. Bolts securing the cleats will extend entirely through the posts and to the outside of the building. Depressions should be arranged in the outside surface of the wall, as indicated in Fig. 1, into which the bolt heads can be set. Pieces of board should be nailed over the depressions so that water from rain or snow cannot drip from the bolt heads and make streaks on the wall. In wooden buildings, small motors can usually be bolted directly to the posts or columns. In buildings of weak construction it is sometimes necessary to build wooden frames, extending from floor to ceiling and strongly braced, to carry motors located on side walls. Although such frames often rest directly against a wall they are structurally independent.

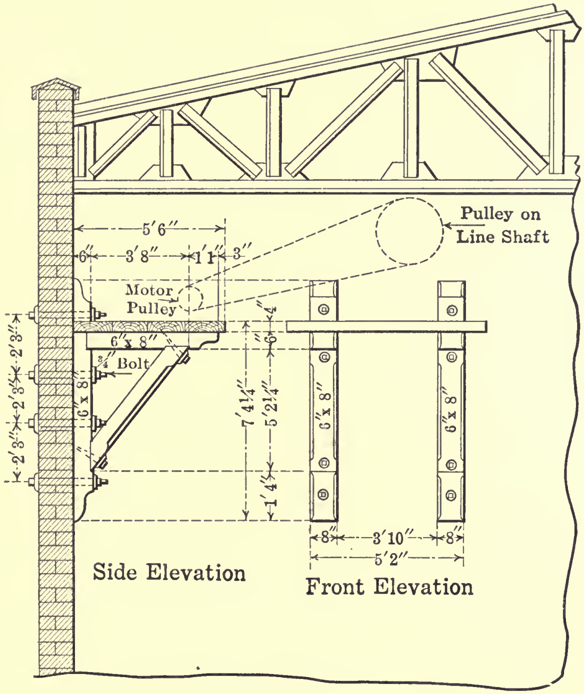


FIG. 2.—WOODEN WALL BRACKETS FOR MOTORS.

Where motors must be located at side walls, it appears to be the present tendency to mount them directly on the walls, as outlined in Fig. 1 rather than on brackets. When a motor is arranged with its bed-plate in a vertical plane the erector should always be certain that the motor end frames are so located in relation to the main frame, that the oiling devices will feed properly. It is the usual practice of electrical machine manufacturers to ship motors with their bed-plates arranged for operation

in a horizontal plane and below the motor frame—that is to say, the motors are ordinarily shipped for floor mounting. A motor arranged for floor mounting can, as a rule, be adapted for wall mounting by removing the end frames (which carry the bearings), rotating them through an angle of 90 deg. and replacing them.

Some erectors prefer to mount motors located at side walls on brackets. A wooden motor-bracket, designed for mounting on a brick side wall, is

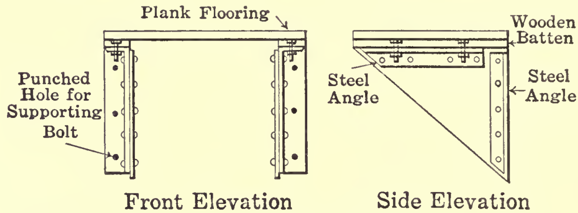


FIG. 3.—STRUCTURAL STEEL BRACKET SUPPORTS.

illustrated in Fig. 2. Brackets of this design were used for supporting 15-h.p. and 20-h.p. motors in the Omaha (Neb.) shops of the Union Pacific Railroad Company. The bolts supporting the brackets extended entirely through the brick walls and each had a substantial washer under its head.

Where many brackets are to be used it is usually economical to have a pattern made and to use bracket supports of cast iron rather than of

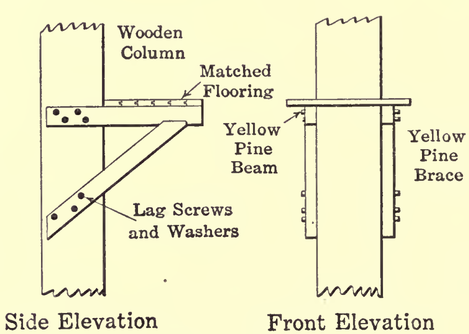


FIG. 4.—WOODEN COLUMN BRACKET.

wood. The pattern for this is easily made in one piece. Holes to accommodate the bolts for binding the supports to a wall and for clamping the bottoms, to which the floor boards are nailed, are drilled in the casting by the erector. Wall-bracket supports can be made of structural steel angles and steel plates, as suggested in Fig. 3. Obviously, steel supports are preferable to cast-iron ones, as for equal strength they are lighter and they are not so brittle. Another point in favor of steel construction is

that when it is taxed beyond its capacity it will give an indication of distress before failing, whereas cast iron may crack without warning. Where facilities are available for shearing plates and structural sections and for riveting them together economically steel bracket supports have much to commend them.

Motors are often advantageously mounted on columns. Fig. 4 shows the construction of a simple form of column bracket. This construction can be used only where motors of relatively small output are involved. The braces and beams are clamped to the column with lag screws, each having a punched washer under its head. Enough lag screws should be used so that there can be no possibility of their working loose. The upper

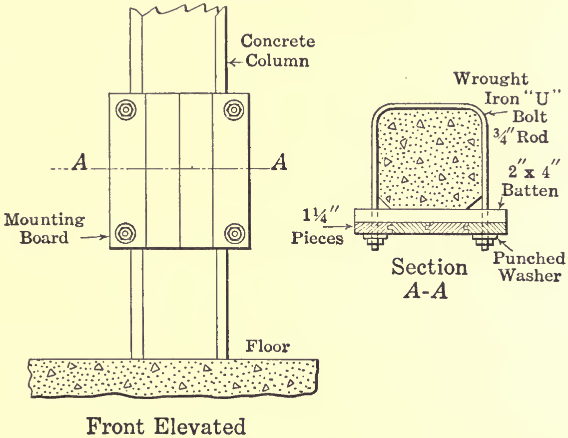


FIG. 5.—MOUNTING BOARD FOR REINFORCED CONCRETE COLUMN.

end of each brace is set about 1/2 in. into the beam and is held there with wood screws. It is well, as a rule, to use matched stock for motor brackets. If plain stock is used it ultimately dries out and shrinks, leaving open spaces between adjacent boards for dust, dirt and probably oil to come down continually through the spaces. This is largely avoided where bracket floors are made of "matched" stock. They can then be cleaned systematically by the motor inspector.

In buildings of reinforced concrete small motors can be mounted on a mounting board like that of Fig. 5. It is sometimes advisable when erecting this kind of mounting board to chip out a groove for each of the "U-bolts" in the rear face of the column. By this expedient any tendency for the mounting to slip down the column is corrected. The wood used should be well seasoned so that there will be but little shrinkage. Starting devices for motors can also be mounted on boards like that of Fig. 5. Obviously, lighter construction may be used for these.

A neat and economical bracket for a structural steel column is illus-

trated in Fig. 6. A steel plate forms the floor or platform and all of the components of the bracket are riveted together. Bolts are used to attach the bracket. A portable, electrically operated breast drill and an "old man" to maintain it in operating position will be found valuable tools

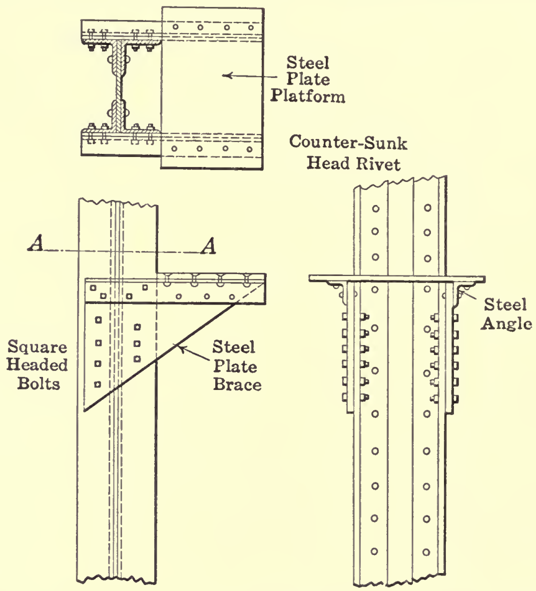


FIG. 6.—STRUCTURAL STEEL MOTOR BRACKET AND COLUMN.

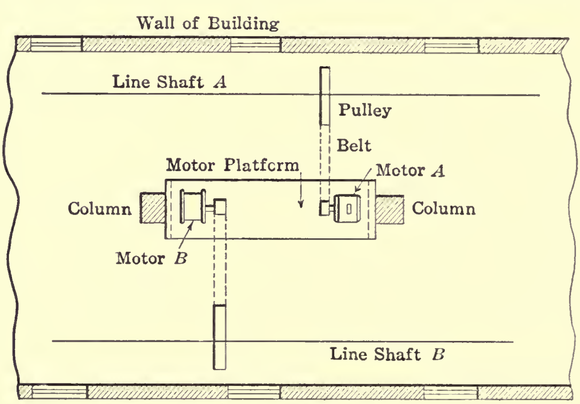


FIG. 7.—MOTOR PLATFORM BETWEEN COLUMNS.

where much drilling is to be done in structural steel members already erected. The outfit will pay for itself in a short time. Where a bracket must be attached to the face of a column instead of to its side it can be arranged like the one shown in Fig. 3. Countersunk-head rivets should

be used to secure the platform plate. Button-head rivets interfere with the locating of a motor bed-plate on a platform.

In arranging group drives it frequently occurs that two motors can be advantageously mounted on one platform, supported by two columns,

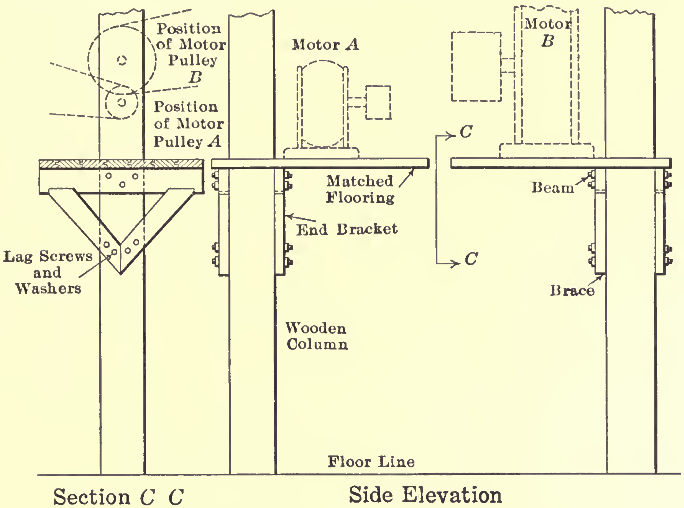


FIG. 8.—WOODEN PLATFORM FOR TWO MOTORS.

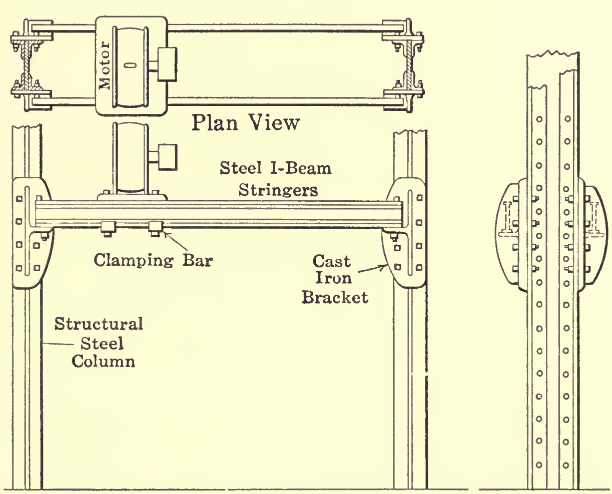


FIG. 9.—STRUCTURAL STEEL STRINGERS AND SUPPORTS.

as indicated in the plan, Fig. 7. The starting device for each motor can be mounted on the adjacent column near the floor. In a wooden building, a platform of this type can be constructed as suggested in Fig. 8. The motors are, if possible, located close to the columns so that the bridge

between the brackets can be made of the lightest material possible and yet be stiff enough to carry the motors.

Stringers made of structural steel I-beams or channels serve to support the motors in steel-frame buildings where two motors can be arranged to drive from between adjacent columns. A typical installation is outlined in Fig. 9. Only one motor is shown on the stringers in the illustration,

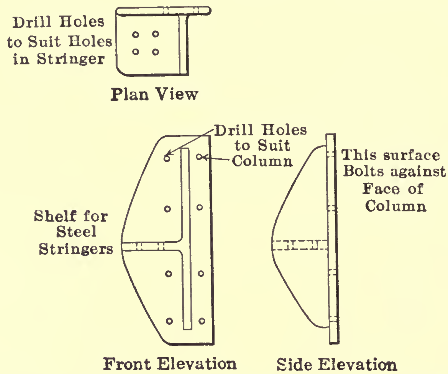


FIG. 10.—DETAIL OF CAST-IRON END BRACKET.

but another or more could be supported. The feature of this method of mounting is the cast-iron end bracket (see Fig. 10 for detail), which carries the stringers at the columns. End brackets can be made from structural steel, but it is not always possible to make them so they can compete in cost with cast-iron ones. It is usually possible to design one cast-iron end bracket that it can be used for a majority of applications about a plant.

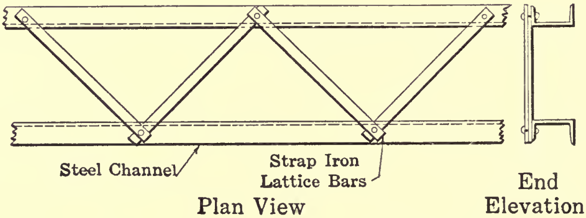


FIG. 11.—LATTICED CHANNEL STRINGERS.

Different drillings will be necessary to adapt the brackets for different columns and stringers, but the same pattern and castings can be used for all. In designing such an end bracket it should be made sufficiently strong to carry the largest motors that it will ever be called upon to bear. This procedure will render it too heavy for supporting small motors, but, unless there are many small motors, it will be more convenient and probably more economical to make all end-bracket castings from the same

pattern. It should be noted that the pattern is of one-piece construction and is easily and cheaply made.

No floor is necessary with the construction shown in Fig. 9. The motor bed-plate is clamped to the stringers, possibly by one of the methods suggested in Figs. 13 and 14. These will be discussed later.

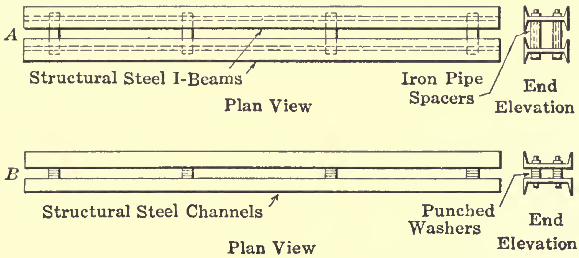


FIG. 12.—ASSEMBLED STRINGERS.

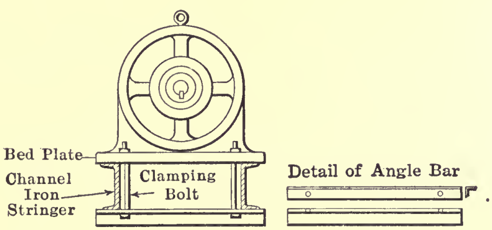


FIG. 13.—APPLICATION OF ANGLE-CLAMPING BAR.

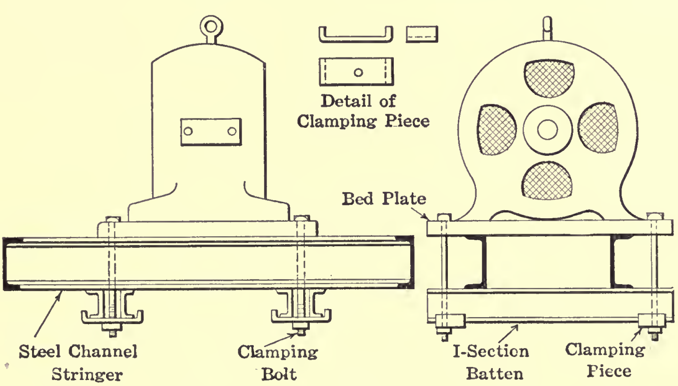


FIG. 14.—CHANNEL-CLAMPING BARS.

The stringers may be single channels (Fig. 11) or single I-beams, or they may be assembled from two or more channels or I-beams, bolted together, as detailed in Fig. 12. If stringers are long and lateral deflection is feared the members may be reinforced with lattice-bars, as shown in Fig. 11. In the assembled stringers of Fig. 12 short lengths of pipe are used as

spacers in the member *A*, which is composed of I-beams, and punched washers are used for *B*, which is made up of channels. If many assembled stringers are to be used it may be cheaper to have regular spacers made of cast iron than to use the pipes and washers.

One of the simplest methods of clamping a motor to steel stringers is outlined in Fig. 13. A length of angle iron, properly drilled, is used

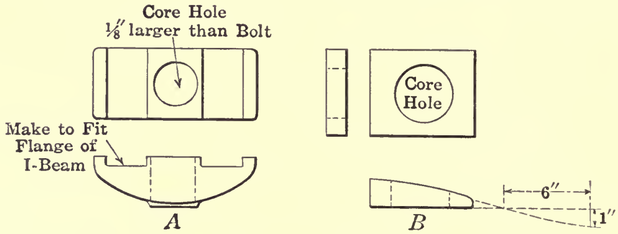


FIG. 15.—BEAM WASHERS AND FLANGE WASHER.

for a clamping bar and standard bolts passing through the motor bed-plate hold the components in correct relation. The method shown in Fig. 14 is sometimes used where large motors are involved. In this case small channels, possibly 3 in. or 4 in. deep, are used for clamping bars. A clamping piece (see detail in Fig. 14) forged from a wrought-iron bar is used to prevent the clamping bars from spreading. If enough will be used to

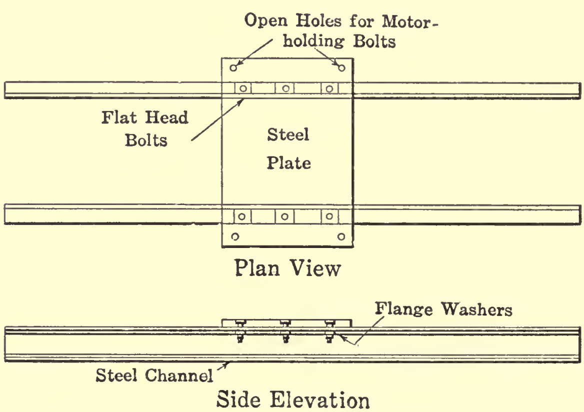


FIG. 16.—STEEL PLATE PLATFORM.

make it worth while to have them cast I-beam washers of iron, similar to that of Fig. 15, *A*, should be used instead of the forged-iron clamping piece shown in Fig. 14.

Sometimes it is convenient to bolt a steel plate for supporting a motor to stringers, as shown in Fig. 16. The plate is drilled for the bolts that hold down the motor bed-plate. Flathead bolts should be used for at-

taching the platform plate to the stringers so that there will be nothing extending from its surface to interfere with the lateral adjustment of the motor. Flange washers (Fig. 15, *B*) which are beveled to fit the insides of flanges of I-beams and channels, are used under the nuts of flat-head bolts.

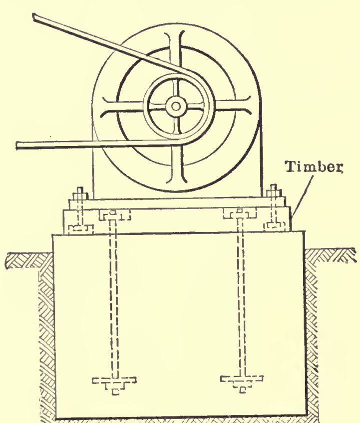
Insulating and Grounding Motors and Generators (By Terrell Croft).—The National Electrical Code specifies that motors and generators operating at pressures in excess of 550 volts must have their base frames permanently and effectively grounded. Motors and generators operating at pressures of 550 volts or less should, so the code specifies, be insulated from the ground wherever feasible, but where the insulation of the frame is impracticable permission may be secured from the local inspection department to omit the frame insulation. However, where such insulation is omitted the frame must be thoroughly grounded.

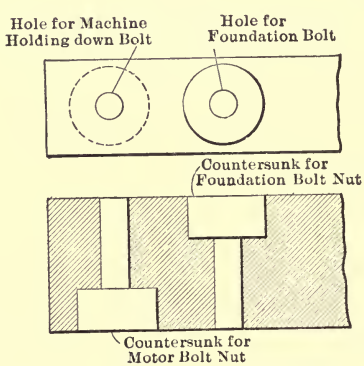
Insulating the frame of a high-voltage machine from the ground introduces a dangerous life hazard, because there may be a leak between the winding and the frame and the attendant touching such a frame can be severely shocked, or possibly killed. Where the voltage is low—below possibly 550—this element of life hazard is not of great moment. It is therefore evident that the frames of all high-voltage machines should be thoroughly grounded, and it is also very likely true that it would be well to ground the frames of all low-voltage machines to protect the attendants from shock.

There is another good reason why it is preferable from the operator's standpoint to ground the frames of all electrical machinery. Consider the case of a frame of a machine insulated from the ground: If a leak occurred in this machine between one of the windings and the frame, the operator would not, in the ordinary course of operation, be advised of its presence, and another ground might occur in the same machine between the winding and the frame, which would make a short-circuit and possibly burn out the machine and produce a fire. If, however, the frame of the machine were thoroughly grounded, a leak between the frame and the winding would make itself known through an indication on the station ground detector, and then it could be readily corrected before another ground could occur and make serious trouble.

The intention of the code rule appears to be that if a frame is insulated it must be thoroughly insulated, and if grounded, thoroughly grounded. If a frame were, however, but imperfectly insulated, sufficient current might, under certain conditions, flow through the high-resistance path constituted by the imperfect insulation and cause a fire. Although the code does not so specify, it is probable that it is always best to ground effectively electrical machinery frames wherever possible, but where effective grounding is not feasible the frame should be thoroughly insulated for the reason just indicated.

It does not appear to be general practice among Underwriters' inspectors rigidly to enforce the code requirement for thorough insulation. Some inspectors appear to pay but little attention to the rule where the pressure is below 550 volts. Where the pressure is in excess of 550 volts, however, thorough grounding is generally insisted upon. Inasmuch as the majority of modern electrical generators are directly connected to their prime movers and are thereby thoroughly grounded through the piping systems serving the prime movers, it is not often that a large generator is not well grounded. Belted motors are frequently insulated owing to being supported on timbers of either a wooden floor or a ceiling. Large motors are usually mounted on a concrete foundation or on the frame of some machine, and in such cases should be thoroughly grounded. Frequently small motors are mounted on the frames of machine tools, and in some cases on small concrete foundations, and hence are not thoroughly insulated, nor can they be said to be thoroughly grounded. In such applications the inspectors appear to ignore the ruling requiring effective insulation or grounding and pass such machines by without comment.



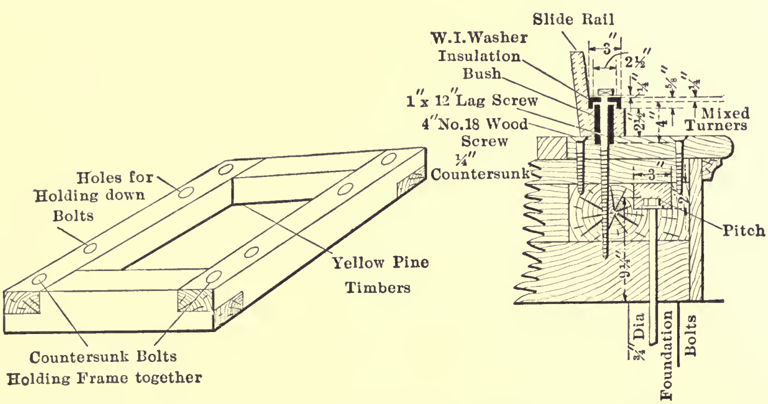


FIGS. 1 AND 2—MOTOR INSULATED ON A PARALLEL TIMBER BASE AND ARRANGEMENT OF BOLT HOLES IN INSULATING TIMBERS.

The most common method of insulating generators and motors is by supporting them on wooden timbers. The wooden-base frames used for this purpose should be thoroughly filled and varnished. Almost any sort of wood will do. Where a wooden floor or ceiling is depended on for insulation it should be thoroughly filled and varnished to prevent the entrance of moisture, although it is not often that such precautions are taken in actual practice. A typical installation of a belted unit insulated on timbers is shown in Fig. 1. The timbers are held to the concrete foundation with long foundation bolts, and additional bolts secure the machine frame, or the slide rails, to the timbers. It is essential that

the foundation bolts and the bolts that fasten the machine be well insulated from each other. Fig. 2 shows the arrangement of the bolt holes in the ends of timbers like those shown in Fig. 1, indicating that a sufficient section of wood must be provided between the two holes to obtain adequate insulation. This section in no case should be less than 1 in., and a greater separation is preferable. As indicated in Fig. 2, it is necessary to countersink the holes for all of the bolts so that the bolt head or the nut, as the case may be, rests well below the surface of the timber. If such holes are not countersunk, the metal of the bolt may come in contact with either the foundation top or the machine frame and defeat the purpose for which the insulating timber is employed.

Another type of insulating base frame that is frequently used, which consists of four sticks held together at their ends by "half-and-half"



FIGS. 3 AND 4.—INSULATING BASE FRAME AND METHOD OF INSULATING SLIDE RAIL.

joints, is shown in Fig. 3. Although base frames of this form are more popular than those like that indicated in Fig. 1, they are not as desirable because dirt and oil are apt to accumulate in the box-like cavity formed by the four timbers. It is often very difficult to remove such débris. With the arrangement of Fig. 1, however, the dirt can be pushed out from the machine frame at either end, and the floor or foundation under the machine can be kept clean with little difficulty. If dirt is allowed to accumulate, it may defeat the purpose for which the timbers were placed, because the timbers may become impregnated with it, which will reduce their insulating qualities.

The insulating frame that was installed under a large low-voltage belted alternator is shown in Fig. 5. For this application an extremely heavy timber frame was required because of the size of the machine,

which was almost 11 ft. long. After the 10-in. by 10-in. sticks composing the sills for the frame were in place and held down with the foundation bolts, a double floor of 2-in. by 2-in. wood planks was nailed to the sills, and on this floor the generator was supported, the slide rails for it being held down with lag screws turning through the floor and down into the sills.

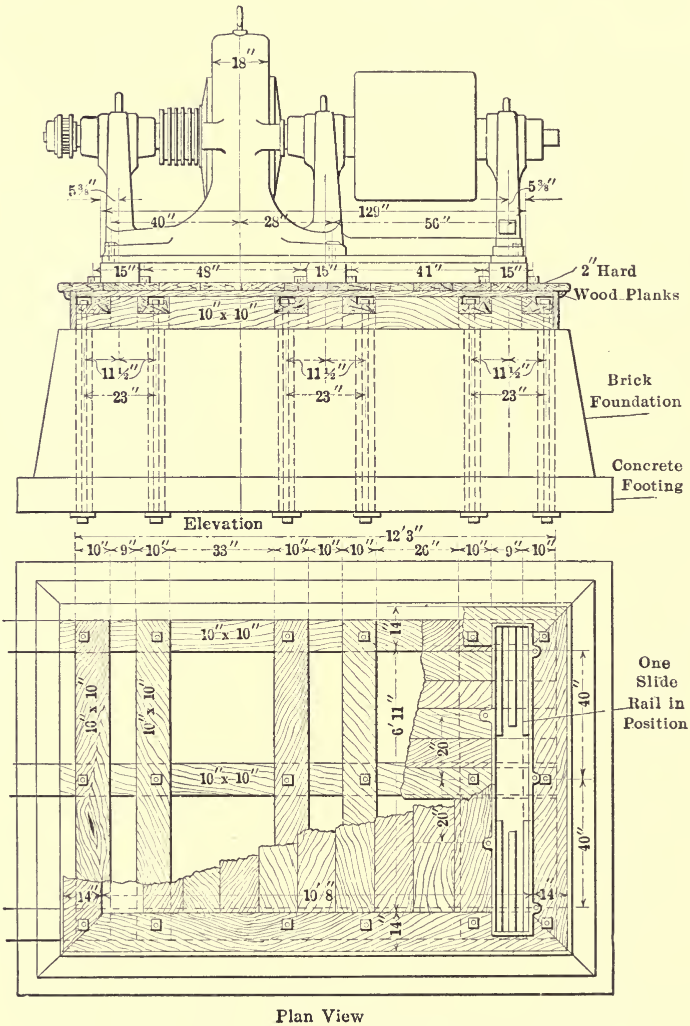


FIG. 5.—INSULATING BASE FOR A LOW-VOLTAGE GENERATOR.

There are often cases where Underwriters' inspectors have insisted that the lag screws holding the slide rails of the machine to the wooden-base frame be thoroughly insulated from the slide rails. The arrange-

ment that has been used in such cases is shown in Fig. 4. The insulating washers and bushings were turned from fiber. The wrought-iron washer should always be placed on top of the fiber washer, as suggested in the picture, to prevent the head of the lag screw from digging into the fiber. In the installation illustrated the countersunk holes in which the nuts on the ends of the foundation bolts turn were filled with pitch to insure further protection.

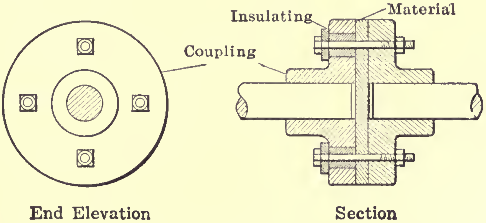


FIG. 6.—TYPICAL INSULATING COUPLING.

Where a motor or generator that is directly connected to some prime mover or machine must be insulated therefrom, it is necessary to insert an insulating coupling in the shaft between the electrical machine and the other machine. The construction of one type of such a coupling is outlined in Fig. 6. A disk, usually of fiber, is bolted between the two faces of the flanged coupling, and the coupling bolts are insulated with washers and bushings, which are also usually made of fiber. Couplings of the type outlined in Fig. 6 are not self-aligning; i.e., the only members that

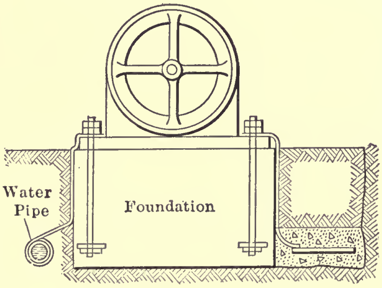


FIG. 7.—GROUNDING A MACHINE FRAME ON A PIPE AND ON A GROUND PLATE.

prevent the two shafts from being forced out of line with each other are the bolts through the coupling. It is necessary, therefore, where a coupling of this type is used, to have a bearing supporting the shaft reasonably close to and at each side of the coupling. It is difficult to design an insulated self-aligning coupling, and where one is designed it is ordinarily quite expensive. Hence it is usually cheaper to provide the additional bearings required with a coupling of simple construction, like

that of Fig. 6, than it is to install a self-aligning bearing and thereby eliminate possibly one or two bearings.

It is practically impossible to insulate a large heavy direct-connected electrical machine in such a way that it will remain in accurate alignment with the prime mover that drives it or the machine that it drives. For this reason it is the almost invariable practice to ground such machines.

Where belt-driven electrical machine frames are insulated from the ground, trouble frequently results from static electricity generated by belt friction, which, because it cannot find a low resistance path to ground through the machine frame, will discharge from the belt driving or being driven by the machine, or may discharge from some portion of the machine frame to a grounded object. While these static discharges may not be dangerous to life, it has been found that they frequently have an injurious

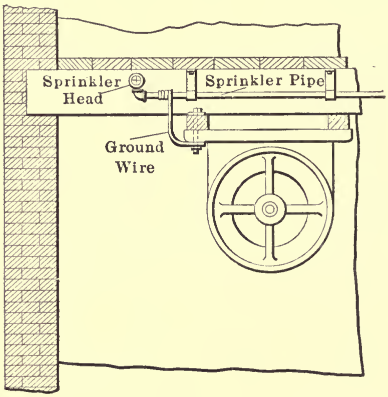
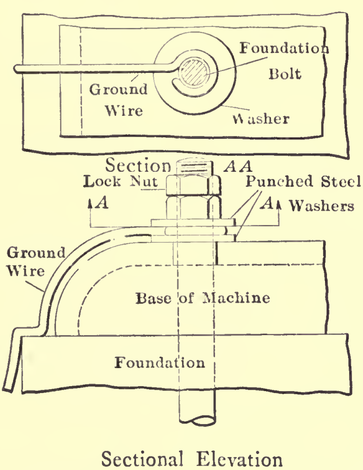


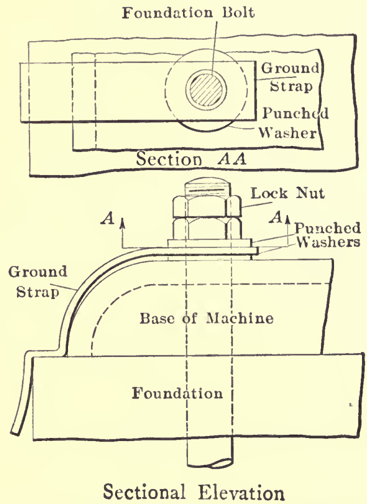
FIG. 8.—MOTOR FRAME GROUNDED TO SPRINKLER PIPE.

effect on the insulation used on the windings and sometimes cause break-downs. A metallic comb, connected to ground, arranged close to but not touching the belt that tends to discharge static electricity, will usually eliminate the discharges, or grounding the frame of the machine, if grounding is permitted, should accomplish the same result. If direct grounding of the frame is not permitted, a high resistance ground, consisting of a long piece of ground-glass having a lead-pencil mark on it, possibly an inch can be used in series between the generator frame and the ground. A sheet-metal terminal should make contact with each end of the pencil mark, and to these metal terminals are connected respectively the leads to the ground and to the frame of the machine. Although the resistance of such a pencil mark is exceedingly high, the static electricity will readily flow through it.

Probably the best method of grounding a frame is to connect it to a water pipe. As noted above, the frames of generators directly connected

to steam prime movers are thoroughly grounded through the steam and exhaust piping to the engine. Fig. 7 shows two methods of grounding the frame of a machine. At the left of the arrangement a ground conductor is connected, in a manner to be described hereinafter, to the frame of the machine and to a water pipe. At the right the ground conductor connects to a metal plate embedded in charcoal. The method of constructing a ground connection with a metal plate and charcoal is described in detail in the National Electrical Code. To be effective the charcoal must always be moist, and it is not always that this condition can be assured. Where a ground connection for any purpose is required and a water pipe is not available, it now appears to be the accepted practice to drive a series of ground pipes into the earth somewhat after the manner indicated in Fig. 11.



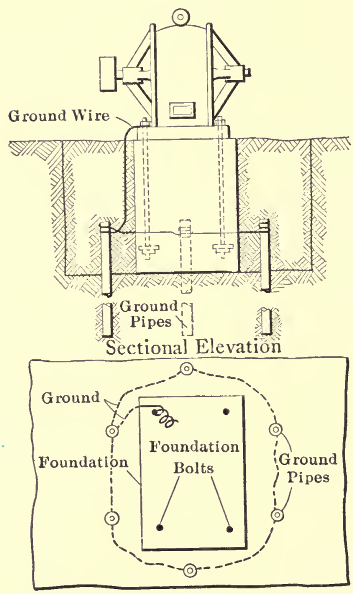


FIGS. 9 AND 10.—METHOD OF CONNECTING GROUND WIRE TO MACHINE, AND METHOD OF CONNECTING GROUND STRAP TO MACHINE.

In Fig. 8 is detailed an installation wherein a motor mounted on a ceiling in an industrial plant is grounded to a sprinkler pipe. In buildings of non-fireproof construction sprinkler pipes are usually available and constitute an excellent method of securing a good ground. Some judgment should be used in grounding a motor frame to a sprinkler pipe. A very large motor should not be grounded on a very small pipe. It is probably permissible to ground a 10-h.p. or 15-h.p. motor to a 3/4-in. branch pipe, but a 50-h.p. motor should be grounded on one of at least 2-in. nominal diameter. The pipe selected should in every case be of such size that there would be no possibility of its overheating when carrying the current which the fuses protecting the motor will safely convey.

Obviously, if the current through the motor frame and ground wire to the sprinkler pipe comes greater than that which the motor fuses will pass, the fuses will blow and open the circuit.

A system of ground pipes for grounding a large capacity electrical machine in a location where no water pipe is available is outlined in Fig. 11. A series of ground pipes, which should extend far enough into the earth so that a good portion of their lower ends will always be in damp soil are driven into the ground around the foundation of the machine.



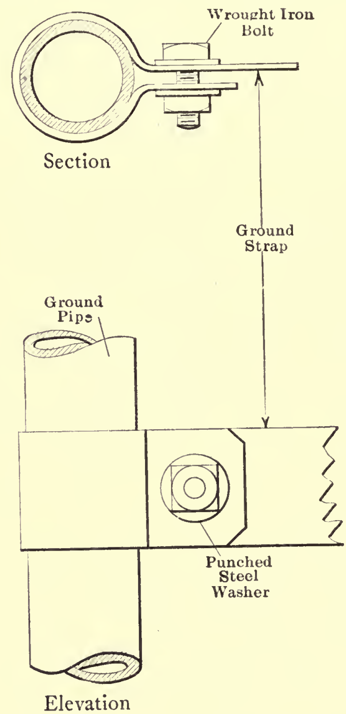


FIG. 11 AND 12. ARRANGEMENT OF GROUND PIPE AROUNR AN ISOLATED MACHINE, AND METHOD OF CONNECTING GROUND STRAP TO PIPE.

These pipes are all connected in multiple with a heavy ground wire, one end of which is carried up to and connected on the frame of the machine. It should be understood that this multiple ground-pipe connection is not nearly so good a one as that provided by a pipe connecting to an extensive water system.

Figs. 9 and 10 show two methods of connecting ground conductors to frames of electrical machines. In Fig. 9 a ground wire is shown. Where wire is used it should always be of sufficient section to carry, without appreciable heating, the current that the fuses protecting the machine

will pass. It should also be of such size that it cannot be accidentally broken. The wire is clamped between two punched washers by a nut turning on the bolt that holds the base of the machine to the foundation. These punched washers should be used to insure effective clamping, and so that the nut in being turned on the bolt will not dig into the wire. It is a good plan to provide, as shown, a lock nut on top of the first nut which will prevent loosening if there is vibration. Sometimes the two punched washers and the end of the ground wire are "tinned" in order to prevent the corrosion that might otherwise be caused at the point of contact between the bare copper and iron. The end of the ground wire should be bent around the bolt in the same direction that the nuts turn on—that is, in a right-handed direction—so that any twisting action due to the nuts will tend to wrap the wire around the bolt rather than to unwrap it. Copper should always be used for ground wire.

A strap of copper is used for the ground connection of Fig. 10. In general, the requirements for the strap as regards mechanical strength and current-carrying capacity are the same as those for a ground wire, as outlined in the above paragraph. Where a large machine is being installed a strap connection is preferable to a wire, because with it sufficient cross-section can be secured in a form that can be readily bent into any desired contour. A large round wire cannot be conveniently formed around the foundation, into the corners and around the bends which it must follow in its route to the earth. Where a strap is used it can be of possibly 1/8-in. thickness and of sufficient width to provide the necessary current-carrying capacity, and it can always be formed without difficulty into any desired contour. The end of the strap clamped between the punched washers and the washers themselves should be "tinned" to prevent corrosion.

A ground wire, if it be not too large, can be connected to the ground pipe with one of the specially designed clamps of which there are many forms in the market. If clamps are not available, the point on the pipe at which it is desired to connect the ground wire should be carefully cleaned, and the ground wire can be soldered thereto. In soldering a copper wire to an iron pipe, the pipe should be filed until it is bright and should be "tinned" by heating it, using powdered sal ammoniac as a flux and applying the solder. The previously "tinned" end of the ground wire is then wrapped around the pipe several times, the whole heated and solder applied.

A ground strap can be connected to a pipe as detailed in Fig. 12. The pipe should be clean at the point where the strap clamps around it, and both the strap and the pipe should preferably be "tinned."

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